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AN EVALUATION OF A NEW FORMAT FOR PRESENTING EJECTION INFORMATI--ETC(U)
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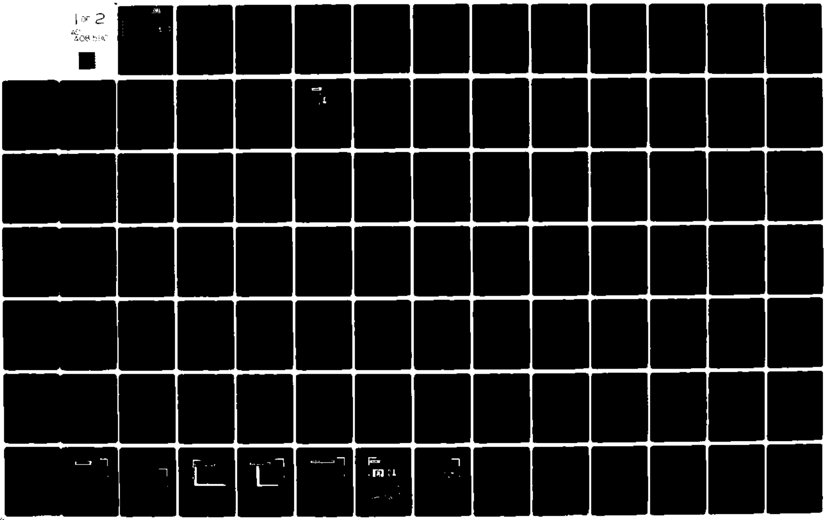

NAVY TECHNICAL INFORMATION PRESENTATION PROGRAM

Contract N00014-77-C-0321
Work Unit No. NR 207-068

AN EVALUATION OF A NEW FORMAT FOR PRESENTING EJECTION INFORMATION IN A NATOPS MANUAL

by
T.J. Post
R.L. Kershner

November 1979

Distribution of this report is unlimited

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle)
6
AN EVALUATION OF A NEW FORMAT FOR PRESENTING EJECTION INFORMATION IN A NATOPS MANUAL

5. TYPE OF REPORT & PERIOD COVERED
9
Final rept.

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)
10
Theodore J. Post
Robert L. Kershner

8. CONTRACT OR GRANT NUMBER(s)
15
N00014-77-C-0321

9. PERFORMING ORGANIZATION NAME AND ADDRESS
BioTechnology, Inc.
3027 Rosemary Lane
Falls Church, Virginia 22042

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
Work Unit No. NR 207-068

11. CONTROLLING OFFICE NAME AND ADDRESS
Crew Systems Division
Naval Air Systems Command
Washington, D.C.

12. REPORT DATE
11
November 1979

13. NUMBER OF PAGES
147
12 138

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)
David W. Taylor Naval Ship Research and Development Center, Code 1803

15. SECURITY CLASS. (of this report)
Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release, distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

Same

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Information Presentation Formats
Hazardous Performance
Time Critical Performance
Technical Manuals
Recallability
Comprehensibility
Aircraft Ejections
Information Retention

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Naval Aviation Training and Operating Procedures Standardization (NATOPS) manuals include procedures for operating equipment under normal and emergency conditions. Invariably, emergency conditions require an immediate and accurate response, demanding that the performer know precisely what to do and when and how to do it. A pilot or crewmember is of course not free to refer to the NATOPS manual under these conditions. Consequently, coverage of emergency procedures should employ formats which maximize clarity, learning, and recall to the highest possible levels so that such procedures are second nature to flying personnel. NATOPS manuals examined, however, were consistently unsatisfactory in this regard.

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This project used the ejection procedures section of the T-2 aircraft NATOPS manual to assess the effectiveness of new techniques to remedy these defects in presenting this type of Technical Information. Specific objectives were to:

- Reformat the ejection section of the T-2 NATOPS manual to conform to state-of-the-art information-presentation techniques
- Compare the difference in performance between subjects using the current NATOPS manual and those using the reformatted materials
- Recommend to the Naval Air Systems Command a course of action based on the results of the evaluation.

The results of the evaluation showed that the groups using the reformatted NATOPS materials outscored the groups using the current NATOPS materials in the content areas of Ejection Envelope Assessment, Ejection Procedures, Post-Egress Procedures, and Equipment Location. Improvement was greatest in the Envelope Assessment area. The evaluation demonstrates that the new approaches to information formatting represent an effective means of improving the learning of ejection information.

FOREWORD AND ACKNOWLEDGEMENTS

The David W. Taylor Naval Ship Research and Development Center (DTNSRDC) is developing a Navy-wide system to improve the presentation of Technical Information associated with hardware systems, the Navy Technical Information Presentation System (NTIPS). In coordination with Crew Systems Division, Naval Air Systems Command, DTNSRDC commissioned this study to determine whether reformatting relevant sections of a pilot's NATOPS manual to incorporate new information-presentation techniques would improve the success achieved in ejecting from disabled aircraft.

The study was conducted as part of an ongoing investigation of ejection characteristics which BioTechnology, Inc., is conducting under contract to the Office of Naval Research and the Bureau of Medicine and Surgery. The Project Monitors, sponsors and participants for the study were:

Dr. A.B. Callahan	– Office of Naval Research
Mr. S. Rainey	– David W. Taylor Naval Ship Research and Development Center
Mr. J. Fuller	– David W. Taylor Naval Ship Research and Development Center
CAPT J.B. Wildman, USN	– Naval Air Systems Command
LCDR J.H. Johnson, MSC, USN	– Naval Air Systems Command
CAPT J.E. Wenger, MC, USN	– Bureau of Medicine and Surgery
CDR R.S. Gibson, MSC, USN	– Bureau of Medicine and Surgery
Mr. G. Mutimer	– Naval Air Systems Command
Mr. D.S. Hurst	– Naval Air Systems Command

We wish to express our appreciation to the personnel of the operational units who provided vital assistance in this project. Special thanks go to the following personnel:

NAS Pensacola, Florida

CDR R.E. Doll, MSC, USN	– Aerospace Medical Research Laboratory
CDR T.W. Quay, USN	– Director of Training Naval Aviation Schools Command
CDR P.A. Furr, MSC, USN	– Aerospace Medical Research Laboratory
LCDR H. Pheeney, MSC, USN	– Naval Aerospace and Regional Medical Center
LCDR D.M. Herron, MSC, USN	– Naval Aviation Schools Command
CAPT T. Lewis, USMC	– Training Squadron 10
LT J.F. Palmer, USN	– Naval Aerospace Medical Institute

NAS Meridian, Mississippi

CAPT R. Zick, USN	– Commander, Training Airwing 1
LT D. Ellerman, USN	– T-2 Standardization Officer, Training Airwing 1
LT G. Banta, MSC, USN	– Naval Aerospace and Regional Medical Center
Mr. Gianakos	– Training Device Instructor

SUMMARY AND CONCLUSIONS

Background and Purpose

Approximately fifteen percent of the crewmembers who must abandon disabled aircraft do not survive (Naval Safety Center, 1976).* This fatality rate has not improved over the past seven years. Accordingly, the Navy has initiated research to investigate alternative approaches to improving ejection survival. This particular study focused on the information formats used in the ejection section of the Naval Aviation Training and Operating Procedures Standardization (NATOPS) manuals, a major source of ejection philosophy, standards, and procedures.

An analysis of ejection accidents indicated that aircrew errors occurred in all phases of the ejection and survival process. The pre-egress phase (viz., envelope assessment and ejection decision) and the survival and rescue phase recorded the highest error rates (Rice & Austin, 1975). A separate study showed that, on the average, about 40% of the ejection fatalities were caused by a delay in initiating ejection (Naval Safety Center, 1976). These data cast suspicion on both the envelope assessment/ejection decision and the ejection procedures (e.g., slow assessment or slow procedure performance could delay ejection).

An analysis of information presentations in a number of NATOPS manuals for operational aircraft provided to guide the ejection-envelope assessment and the equipment operation showed faults in both sections. Accordingly, a program was initiated to evaluate the effect of an improved Technical Information presentation format.

This project was supported jointly by the David W. Taylor Naval Ship Research and Development Center (Code 1803) and the Naval Air Systems Command (Code 531).

Approach

The ejection section of the T-2 aircraft NATOPS manual was selected as the test vehicle of the investigation. State-of-the-art techniques were applied to improve the relevant information presentations of this NATOPS manual. An experiment was designed in which a control group of student pilots and naval flight officers studied the conventional presentations while an experimental group studied the improved presentations. Tests covering four information-content areas were used to assess the effect of the modifications on initial learning and retention. The four information-content areas were (1) Ejection Envelope Assessment, (2) Ejection Procedures, (3) Post-Egress Procedures, and (4) Equipment Location.

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*References are listed on p. 24.

Findings, Conclusions, and Recommendations

The experimental group, using the modified information presentations, outscored the control group in all four information content areas. In the all-important area of Envelope Assessment, students who studied with the new material significantly outscored the students who studied with the old presentations.

This study shows that the presentation techniques used in this evaluation represent an effective and inexpensive means of improving the learning of ejection information. It is recommended that steps be taken to make available to the Fleet ejection information prepared in the formats developed in this study.

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INTRODUCTION

Problem

Figure 1 shows a downward trend in recent years in the survival rate for aircrewmen who have ejected from disabled naval aircraft. This trend has occurred despite attempts to improve the ejection hardware. Undoubtedly there is an upper limit to survival rate; that is, uncontrollable circumstances contribute to ejection fatalities. However, official statistics from the Naval Safety Center show that, on the average, about 40% of the ejection fatalities are caused by delay in the initiation of the ejection (NSC, 1976). Such delays result in the aircraft moving beyond the limits of the ejection system; i.e., speed, altitude, or attitude are beyond the limits established for safe ejection.

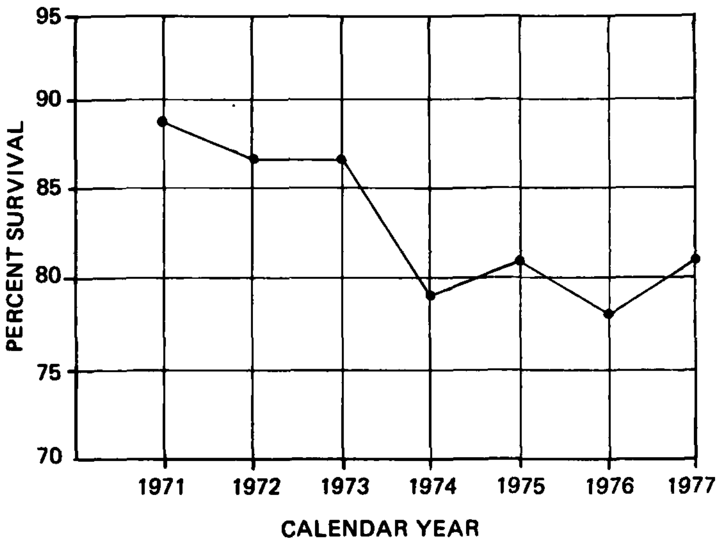


Figure 1. Ejection survival percentages. (Adapted from *Emergency Airborne Escape Summary* (1975); Naval Safety Center, 1976)

Every and Parker's data (1974) identified a number of egress difficulties experienced during Navy combat ejections (see Table 1). These problems were primarily procedural and were affected by environmental factors such as: darkness (no visual reference); fire, smoke, or fuel in the cockpit; and disorientation. Table 1 separates the data on crewmen recovered prior to capture by the enemy from data on prisoner-of-war cases, to reveal any potential effect of these different ejection circumstances.

Table 1

Egress Difficulties (Every and Parker, 1974)

Egress Difficulty	Percent[a] of Recovered Crewmembers Reporting Cited Difficulty	Percent of Prisoner-of-War Crewmembers Reporting Cited Difficulty
Buffeting	11	11
G forces	8	27
Windblast	20	24
Difficulty locating canopy jettison mechanism	1	1
Difficulty releasing canopy/hatch	3	2
Failure to release canopy/hatch	2	0
Difficulty locating/reaching normal ejection mechanism	7	17
Difficulty locating/reaching alternate ejection mechanism	2	4
Face curtain failed to activate seat	2	4
Face curtain problem (locating, reaching, etc.)	2	12
Seat pan firing handle failed to activate seat	2	5
Seat pan firing handle problem		1
Canopy jettison failure (automatic means)	4	4
Confusion, panic, disorientation	1	2
Darkness - no visual reference	3	4
Fire/smoke/fuel	10	12
Upper extremities hit cockpit structures	3	9
Lower extremities hit cockpit structures	7	7
Man struck canopy/canopy bow	3	1
Flailing — upper extremities	13	17
Flailing — lower extremities	13	12

[a]Multiple answers were permitted, so that percentages do not add up to 100%.

Purpose

The foregoing studies suggest a potential for improving crewmember performance in two critical ejection areas: decisionmaking and ejection-equipment operation. To achieve this improvement, the study reported herein focused on the information-presentation formats used in the ejection section of the Naval Aviation Training and Operating Procedures Standardization (NATOPS) manuals. These manuals, written for all operational aircraft, are a major source of user information on ejection philosophy, standards, and procedures.

Approach

The current study examined relevant parts of selected NATOPS manuals to determine whether their presentations included formatting which has been shown to facilitate learning, recall, and usability. These formatting rules were taken from Booher, 1972; Post, 1976; Post and Price, 1974; and Sitterley, 1974. Table 2 shows that seven formatting rules were violated consistently in all procedural presentations, and that the manuals erred consistently on rules relating to pictorials. Table 3 shows the violation trends of the five sample NATOPS manuals when assessed in terms of formatting rules relating to decisionmaking (these formatting rules were drawn from the sources cited above, or developed as "logical" during the study). It is evident that the state-of-the-art practices have not been used consistently in preparing the ejection portions of the NATOPS manuals. These analyses suggest the following hypothesis: *consistent use of selected formatting rules, the effectiveness of which has been demonstrated, will improve the learning and recall of knowledge related to the decision to eject and the procedures for operating the ejection hardware.*

The remainder of this report describes an experiment conducted to investigate this hypothesis. In conceiving the experiment it was decided to use relatively naive subjects. Accordingly, the experiment was designed around the NATOPS manual for the T-2 aircraft, which is used in training student naval aviators and student naval flight officers. The following sections cover: documentation improvements, evaluation methodology, results, and discussion. The following Appendices are included:

Appendix A. Statistical Analysis of Results
Appendix B. Development of Tests Used in Study
Appendix C. Ejection Section of NATOPS Manual for T-2 Aircraft – Unmodified Version
Appendix D. Ejection Section of NATOPS Manual for T-2 Aircraft – Rewritten Version
Appendix E. Opinions of Subjects Regarding NATOPS Ejection Presentation

Table 2

Compliance of Five Sample Ejection Presentations (Procedural) With State-of-the-Art Format Rules

Abbreviated Statements of Format Rules	Aircraft NATOPS Manuals				
	F-14A	A-7A/B	AV8A-1	F-4J	T-2A/B
1. Isolate steps	✓	O	O	X	O
2. Six steps per frame	✓	✓	✓	✓	✓
3. No more than two or three thoughts per step	✓	✓	✓	✓	✓
*4. Illustrate each equipment feature	X	X	X	X	X
*5. Label relevant equipment features	X	X	X	X	X
*6. Not more than six labels per illustration	X	X	X	X	X
*7. Illustration and text next to each other	X	X	✓	✓	✓
*8. Use line drawings, not photographs	✓	✓	✓	✓	O
*9. Illustrate user's view	X	X	X	X	X
*10. Show hands or body features	X	X	X	O	✓
11. Use 2nd-person imperative	✓	✓	✓	✓	✓
*12. Use blow-ups to aid recognition	X	✓	X	X	X
*13. Use minimum dimension of 1/4 inch	X	X	X	X	X
14. Use familiar words	✓	✓	✓	✓	✓
15. Be explicit in describing user action	✓	✓	✓	✓	✓

✓ = OK.
O = Violates occasionally.
X = Violates consistently.
* = Illustrations involved.

Table 3

Compliance of Five Sample Ejection Presentations (Envelope Decision) With State-of-the-Art Format Rules

Abbreviated Statements of Format Rules	Aircraft NATOPS Manuals				
	F-14A	A-7A/B	AV8A-1	F-4J	T-2A/B
1. Use graphic as primary	✓	✓	X	X	✓
2. Use narrative to support graphic	X	X	X	X	✓
3. Use directive form of instructions	✓	✓	O	O	X
4. Minimize need for calculations or translations prior to use	X	✓	X	X	X

✓ = OK.
O = Violates occasionally.
X = Violates consistently.

DOCUMENTATION IMPROVEMENTS

The reformatting of the ejection information in the NATOPS manual for the T-2 aircraft[1] was based on the concept that presentation of technical information on emergency procedures should maximize clarity, learning, and recall, since the crewmember is not free to refer to the manual during emergencies. The following discussions cover the new formats for both the decision and procedural presentations.

Ejection Decisionmaking

Technical information to support decisionmaking should provide a *structure* to show the types of decisions to be made, their order, and the major themes to be accounted for; and guidelines or *standards* to guide individual decisions. Current NATOPS manuals do not provide such a structure, and provide only complex presentations of the standards. The decisionmaking guidance that appeared in the T-2 NATOPS manual was revised to incorporate these features. The specifics of these revisions are discussed below.

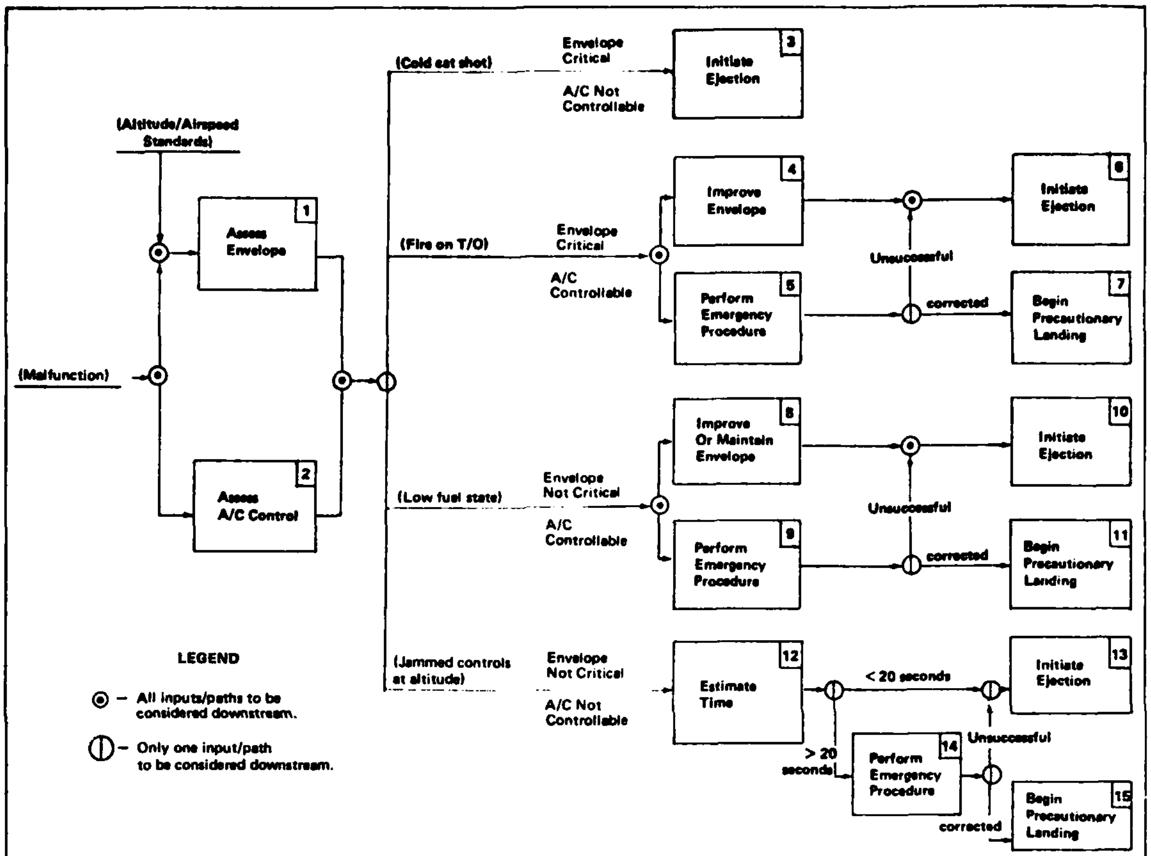
Structure. The revised write-ups were designed to provide a structure to organize and channel the decisionmaking process. The structure brought into balance two conflicting themes: (1) the need to save the aircraft, and (2) the need to perform a timely ejection, if necessary. This decision process was described using a decision-tree format (Figure 2) including sample ejection scenarios (in parentheses).

Standards. The revised write-ups offer two types of standards to guide ejection decisionmaking. One set is "conservative" (a large safety margin), while the other is "literal" (no safety margin). This dual-standard concept is compatible with current ejection philosophy, which states that the probability of a safe ejection decreases as one approaches the limits of the envelope. An innovative feature of the literal-standard presentation that was prepared deals with improvement of their usability. In the past, literal standards have been presented as multi-parametric graphics, difficult or impossible to memorize and recall for inflight use. Simple rules were devised to approximate the product provided by the more complex graphics. Samples of both types of standards appear in Figure 3.

Operating Procedures

When it is necessary to eject, the user must operate the hardware quickly and without error. To help the user achieve this performance level, descriptions of equipment-operating procedure should emphasize *organized sequences* and *pictorial descriptions*. The existing NATOPS write-ups

[1]The T-2 aircraft is used in the Basic Jet and Carrier Qualification phases of flight training. The T-2 is a twin-engine, tandem aircraft with modest performance capabilities. The aircraft is equipped with a North American ejection system occurring in the LS-1 or LS-1A configuration.



This figure presents the ejection decision in diagrammatic form. As shown in blocks 1 and 2, the decision is made on the basis of: (1) envelope assessment *and* (2) aircraft controllability. Envelope assessment is defined as a judgment on how close the aircraft is to the operating limits of the ejection system. The outcome of this assessment can be either *critical* (near or beyond the limit) or *not critical*. Simultaneously, block 2 of the diagram calls for considering aircraft controllability to determine whether it is possible to maintain a good envelope or to improve a critical envelope. The outcome possibilities of this judgment are either: *controllable* or *not controllable*. The results of both judgments are combined giving the four possibilities shown immediately after blocks 1 and 2.

The objective in applying this part of the ejection procedure is to characterize the aircraft situation as one of these four conditions. The emergency noted atop each condition is meant to typify that condition possibility. For example, "fire on takeoff" is characterized as critical envelope, aircraft controllable. Under these circumstances the pilot should simultaneously improve his position relative to the envelope and perform appropriate emergency procedures. If the emergency procedure resolves the problem, a precautionary landing is indicated. If the emergency persists, ejection can be initiated under improved envelope conditions.

Figure 2. New ejection decision-making structure.

did not include these features. Accordingly, relevant passages were revised to incorporate the desired performance-fostering presentation features.

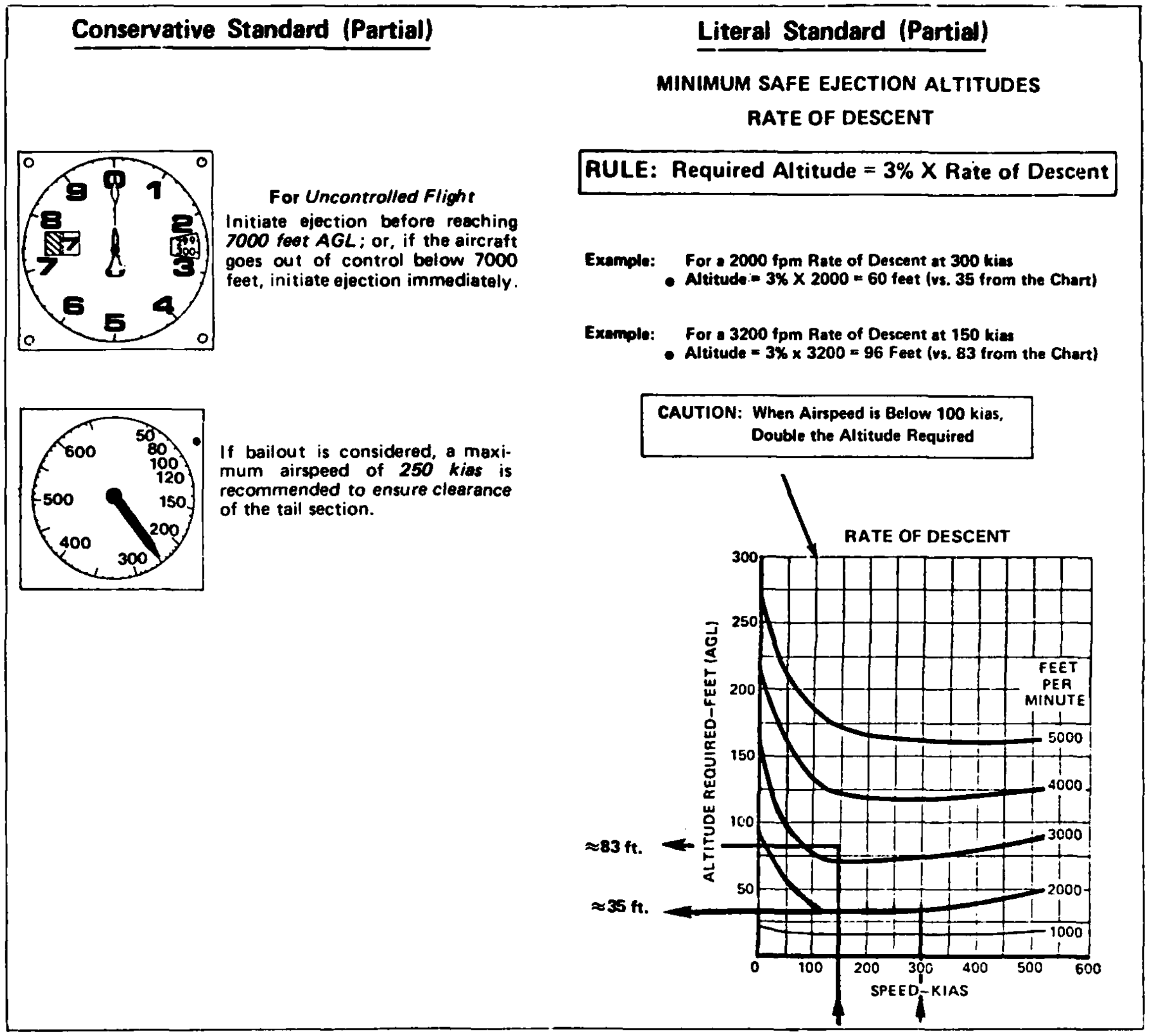


Figure 3. New ejection decision-making standards.

Organized Sequences. To facilitate learning and recall, the steps of a procedure should be presented in organized sequences to break the procedure into small, manageable chunks. The organized sequence used to improve the NATOPS ejection procedure is represented in Table 4.

Table 4

Organization Used to Present Emergency Procedures

I. PREPARATORY	II. EJECT	III. DESCENT
A. Communicate	A. Initiate Ejection	A. Parachute Opening
B. Adjust Equipment	B. Note Automatic Events	B. Prepare for Landing
C. Position Body	C. Initiate Alternate Sequence	C. Landing
	D. Initiate Bailout	

Pictorial Descriptions. Presentations with pictorial support tend to be better understood and remembered than those which rely heavily on verbal descriptions. Sitterley (1974) demonstrated that careful structuring of visual cues was sufficient to "key" the "appropriate" pilot response, even though these cues were presented in a static (still) form. Figure 4 illustrates this format feature with a "before-and-after" comparison of the Position Body action (1C of Table 4) of the T-2 NATOPS ejection procedure.

The rewrite techniques discussed above were applied in reformatting the ejection-relevant portions of the Emergency Section of the T-2 NATOPS manual. The resulting write-up was then evaluated to determine whether the desired learning and recall improvements had been achieved. Appendices C and D present, respectively, the original and rewritten versions of the Emergency Ejection information for the T-2 aircraft. The methodology used in this evaluation is summarized in the next section.

– BEFORE MODIFICATION –

EJECTION

1. CHECK COMMAND COCKPIT EJECTION SELECTOR — BOTH EJECT.
2. IF TIME PERMITS WARN CREWMAN AND FOLLOW RADIO DISTRESS PROCEDURE
3. LEVEL WINGS AND MINIMIZE RATE OF DESCENT
4. POSITION FOR EJECTION: BACK STRAIGHT, CHIN UP, AND BALLS OF FEET ON RUDDER PEDALS
5. TO EJECT:

PULL D-RING

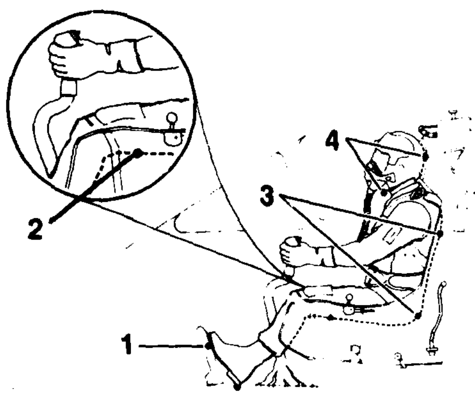
– AFTER MODIFICATION –

I. PREPARATORY

C. Position Body for Ejection

1. Place heels on deck and balls of feet on rudder pedals (1)
2. Move knees outboard with thighs as flat as possible on seat cushion (2)
3. Push buttocks back, sit erect (3)
4. Move head back against headrest and hold chin up (4)

WARNING: Incorrect posture increases your chances of injury during ejection



(Note: the **AFTER MODIFICATION** presentation includes more detail than the **BEFORE MODIFICATION** presentation, and covers fewer steps at a time. This less concentrated presentation aids learning and recall.)

Figure 4. Pictorial emphasis in the new NATOPS write-ups.

EVALUATION METHODOLOGY

Overview

The evaluation was designed to determine how much subjects learned and retained from an independent (at-home) study of either the current or improved ejection presentations. Two separate subject populations were employed for these tests: (1) an untrained group of student naval flight officers (SNFOs) and (2) a group of student naval aviators (SNAs) experienced in the T-2. The response of both groups to paper-and-pencil tests was one means of assessing the learning effectiveness of the NATOPS presentations. In addition, the SNAs were assessed on their response to ejection scenarios presented in an operational flight trainer (OFT).

Subjects

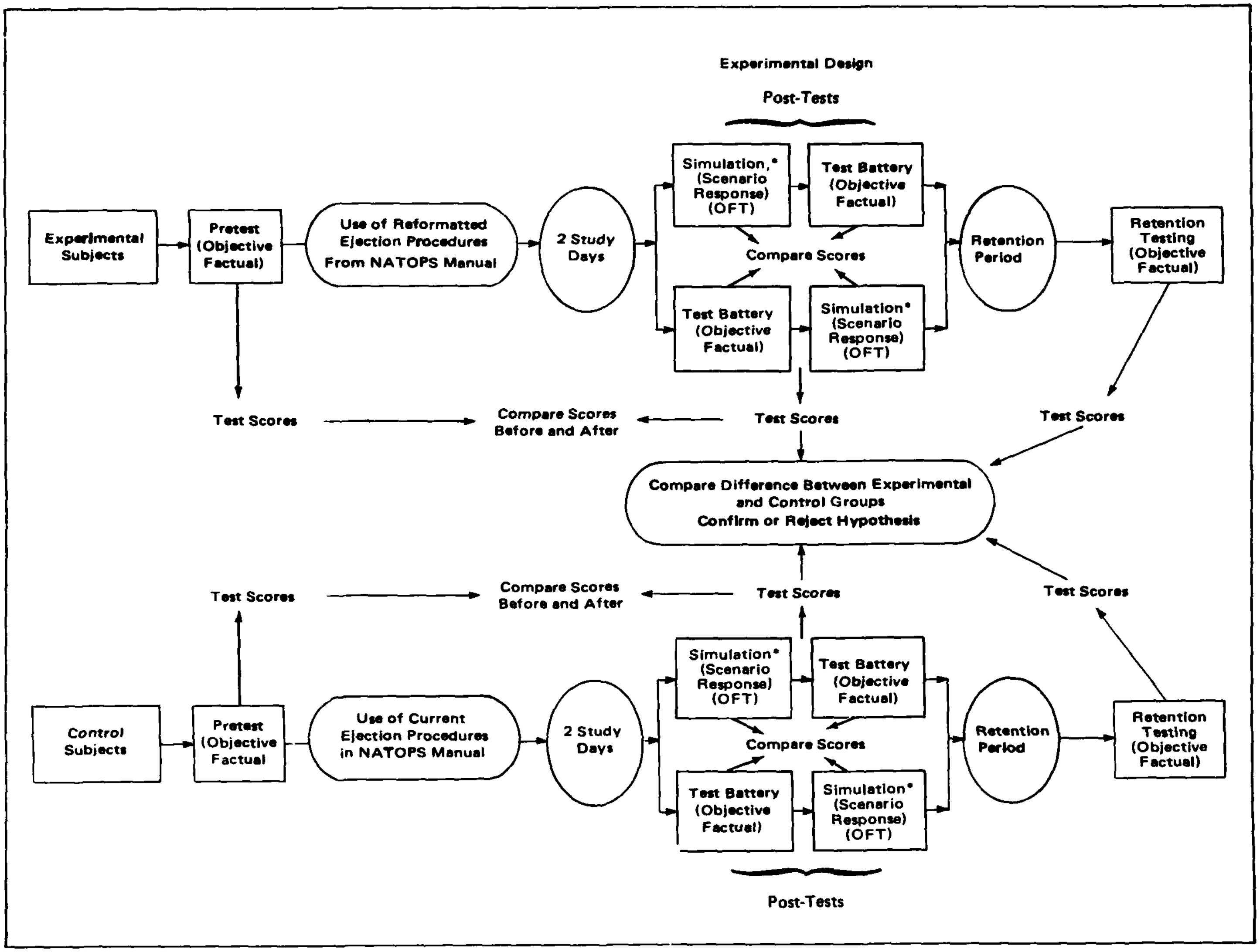
Eighty-seven SNFOs assigned to a pre-training pool participated in the evaluation. The SNFOs were randomly assigned to each of two test conditions: 42 were placed in the experimental group and 45 in the control group. Thirty-eight SNAs were selected randomly from the population of T-2 student pilots whose extent of training ranged from having soloed the T-2 aircraft (8th week of training) to having completed the T-2 training (20 weeks). The SNAs were divided into two groups, with 22 assigned to the experimental condition and 16 to the control condition.

All subjects participated in three paper-and-pencil evaluation sessions. They were informed prior to the first session that they would be used in testing information-presentation techniques covering the ejection procedures section of the NATOPS manual. They were requested not to discuss the study material with each other for the duration of the testing.

Evaluation Procedures

The experimental design is outlined in Figure 5. The exhibit shows three key phases in the evaluation procedure: pretest, post-test, and retention test. The SNFO and SNA evaluation procedures paralleled one another closely, with two exceptions:

- During the post-test period, the SNA sample was exposed to a simulator test (OFT) in addition to the paper-and-pencil tests. A counterbalanced design was employed to account for possible effects of the order in which the tests were given (see Fig. 5).
- The retention period used was 48 hours for the SNFO evaluation, and 7 days for the SNA evaluation. These retention periods were dictated by subject availability.



*SNAs only.

Figure 5. Evaluation procedure.

A 20-minute paper-and-pencil pretest was administered to the subjects immediately following a briefing which outlined the purpose of the testing. After the pretests, the ejection write-ups were distributed. The subjects in the experimental group received the ejection write-ups with the new formatting techniques. The control group received copies of the existing T-2 ejection section. Subjects in each group were requested to study their presentations at home and report back to the test room in 48 hours for the post-test. An informal survey showed that the SNFOs and SNAs tested had actually studied the material for somewhat less than two hours during this period. Upon completing the post-test, subjects were requested to return, after their appropriate retention period had elapsed, for the retention test session. Their participation ended with a short debriefing.

Test Instruments

Paper-and-Pencil Test Sessions. The pretests, post-tests, and retention tests were divided into four separate content areas:

- Envelope Assessment—the subject's awareness of ejection system limits and knowledge of the specific principles and relationships involved in the ejection decision.
- Ejection Procedures—knowledge of the normal and alternative steps necessary to prepare for ejection and operate the ejection hardware.
- Post-Egress—knowledge of the procedures and techniques for parachute deployment, descent, and landing over terrain or water (includes seat-man separation).
- Equipment Location—the ability to recognize and locate equipment involved in all aspects of safe and efficient ejection.

Each of the three tests[2] included four types of items: multiple choice, fill-in-the-blank, picture labeling (see Figure 6), and analytic items labeled "situation-specific" (see Table 5).

The pretest was designed to determine the baseline levels of the subject's knowledge of the four content areas. The post-test used paper-and-pencil tests (and simulator tests for the SNA subjects) to measure the effect of studying the technical information provided on the ejection process. The final paper-and-pencil test assessed the subject's ability to recall the learned technical information after a retention period had elapsed. Additional discussion of test development, validation, and reliability can be found in Appendix B.

[2]A complete set of paper-and-pencil test instruments appears at the end of Appendix B.

5. Locate:

(a) Canopy locks

(b) Emergency canopy release handle

(c) Emergency restraint release

(d) Command selector handle

(1) Is it in "Both Eject" position? (circle one) yes no

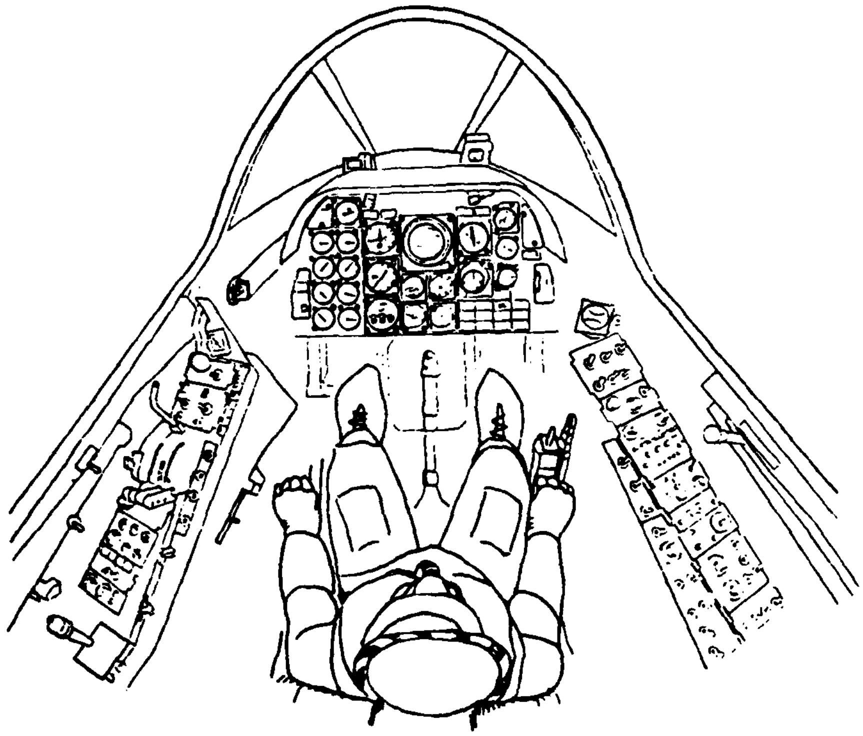


Figure 6. Equipment location test item.

Table 5

Sample of Situation-Specific Test Item
(Envelope Assessment)

Test Section I

1) Situation: You lost control of the aircraft at 10,000 feet. Attempts to regain control have been unsuccessful. Your flight conditions are:

- Rate of descent 5000 fpm
- Airspeed 350 KIAS
- 60° Adverse Angle
- Dive Angle 15°
- Altitude 8000 feet

a) Under these conditions the minimum altitude required for safe ejection is ____________ feet.

b) Describe the basis for your response to Question 1 above ____

____

____

____

____

Simulator Test Sessions. The T-2 Operational Flight Trainer was used to present two ejection scenarios to the SNA subjects participating in the experiment. These scenarios were: "fire on take-off" and "loss of power in descent" (Appendix B). Figure 7 represents the loss-of-power scenario, including probable decision points. The scenarios were developed with the cooperation of T-2 instructor pilots. The responses of the SNAs to the scenarios were recorded in a checklist format by instructor pilots.

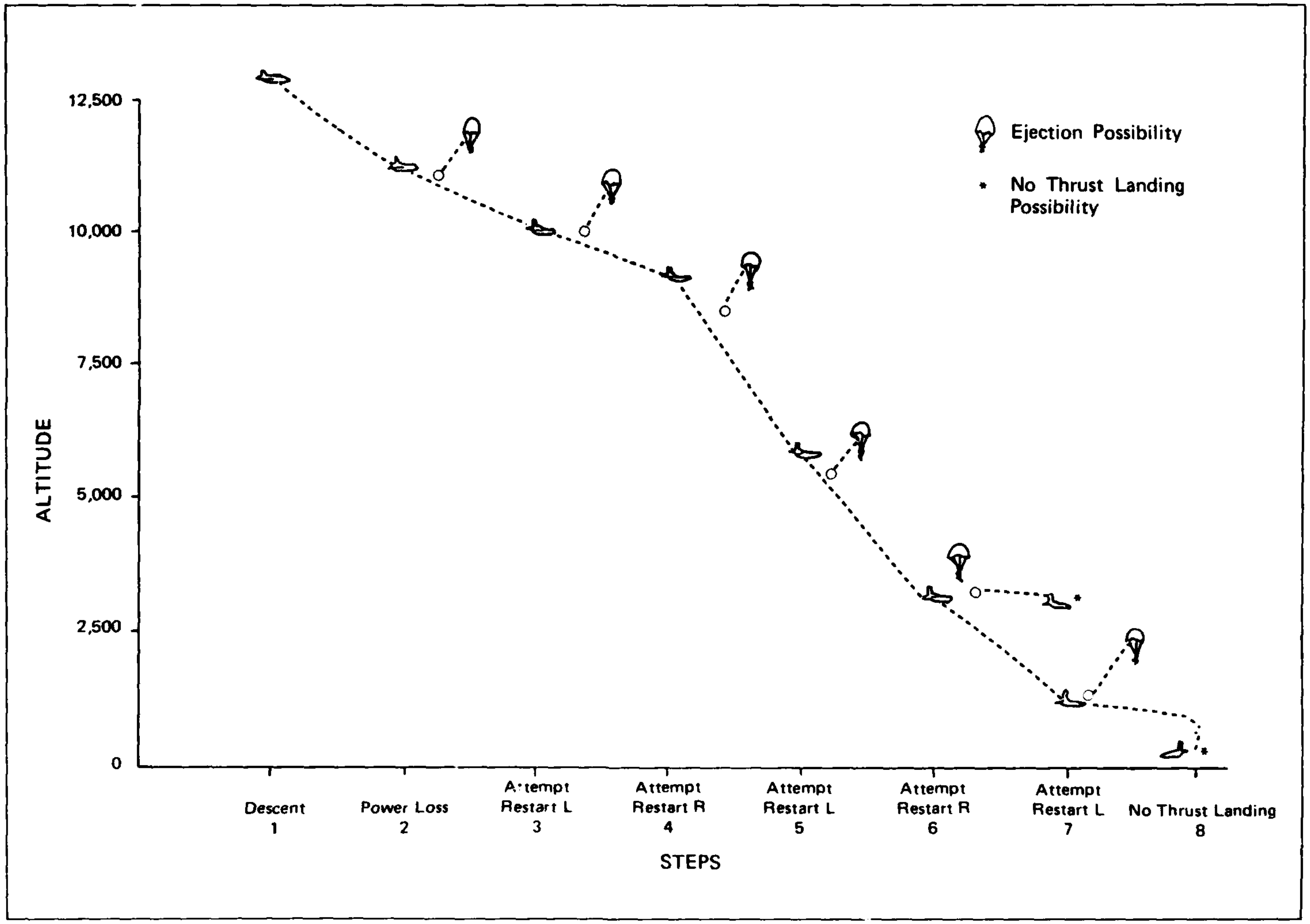


Figure 7. Loss-of-power-in-descent scenario used in OFT simulator tests for SNAs.

RESULTS

The evaluations were designed to show whether the reformatted version of the ejection information for the T-2 aircraft was more effective than the current NATOPS presentations, with effectiveness measured in terms of initial learning, retention, and net information gain. The results of the analysis[3] are summarized in Table 6, Table 7, and Figure 8.

Paper-and-Pencil Tests

Three paper-and-pencil tests were used to measure initial learning, retention, and net information gain. *Initial Learning* was measured by the differences in scores attained in the pre- and post-tests; *Retention* was measured by the differences in scores attained in the post- and retention tests; and *Net Information Gain* (Net Gain)[4] was measured by the differences in scores attained in the pre- and retention tests. Table 6 gives the average test scores obtained for the four content areas, for both experimental and control groups of SNFOs and SNAs. Table 7 indicates the direction and statistical significance of these score differentials for the four study groups. Observations about these measures are as follows:

- Statistically significant net information gains were found in all four content areas for the experimental group of SNFOs and in three of four content areas for the experimental group of SNAs. The "no change" status demonstrated by the SNA sample is in the Equipment Location content area, where the modest but statistically significant initial learning improvement was eliminated by the minor loss during the retention period.
- Study of the existing T-2 ejection section that was presented to the control groups showed little value in the overall pretest/retention test evaluations. The only statistically significant net information gain recorded for the control subjects occurred in the Procedures content area for the SNFOs, with a gain from pretest to post-test and no appreciable loss from the post-test to the retention test.
- The numerical results columns of Table 7 present both verbal and numerical descriptions of the gains or losses for each of the three learning effects. This part of the exhibit shows that the experimental presentations produced results consistently superior to those of the conventional presentation.

Figure 8 is a graphic summary of the differences between the experimental and control groups; it also displays the magnitude of the learning improvements produced by the experimental formats.

- In all eight post-test conditions, the experimental groups' performance (squares) was better than the performance of the control groups (circles), by magnitudes which were statistically significant, as indicated by the ovals. The consistency between pretest baseline levels of the experimental and control groups indicates the homogeneity of the samples used in the study, as well as the level of performance of the subjects entering into the evaluation.

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[3]A detailed presentation of the statistical analysis with charts and tables is included in Appendix A.

[4]Specifically, Net Information Gain = Average % Answers Correct (Retention Test) – Average % Answers Correct (Pretest).

RESULTS

The evaluations were designed to show whether the reformatted version of the ejection information for the T-2 aircraft was more effective than the current NATOPS presentations, with effectiveness measured in terms of initial learning, retention, and net information gain. The results of the analysis[3] are summarized in Table 6, Table 7, and Figure 8.

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[3] A detailed presentation of the statistical analysis with charts and tables is included in Appendix A.

[4] Specifically, Net Information Gain = Average % Answers Correct (Retention Test) – Average % Answers Correct (Pretest).

Table 6*
Test Scores (expressed in percent correct)

	Pretest	Post-Test	Retention Test
		Envelope Assessment	
Student Pilots (SNAs)			
Experimental	58	78	71
Control	63	63	62
Student NFO (SNFOs)			
Experimental	10	68	66
Control	14	27	19
		Ejection Procedures	
Student Pilots (SNAs)			
Experimental	73	85	84
Control	70	78	72
Student NFO (SNFOs)			
Experimental	55	72	70
Control	43	57	53
		Post-Egress	
Student Pilots (SNAs)			
Experimental	77	93	88
Control	79	86	81
Student NFO (SNFOs)			
Experimental	61	83	78
Control	62	77	60
		Equipment Location	
Student Pilots (SNAs)			
Experimental	86	94	93
Control	84	86	87
Student NFO (SNFOs)			
Experimental	52	77	70
Control	41	45	44

*See Figure 9 for simulator testing scores.

Table 7

Summary of Results

	Initial Learning	Retention	Net Gain (Loss)	Numerical Differences in Test Score Results (%)[a]		
	Pretest to Post-Test	Post-Test to Retention Test	Pretest to Retention Test	Initial Learning	Retention[b]	Net Gain
ENVELOPE ASSESSMENT						
STUDENT PILOTS (SNAs)						
Experimental	↑	ϕ	↑	+20 Gain	−7 No loss	+13 Net gain
Control	ϕ	ϕ	ϕ	ϕ No gain	−1 No loss	−1 No change
STUDENT NFO (SNFOs)						
Experimental	↑	ϕ	↑	+58 Gain	−2 No loss	+56 Net gain
Control	↑	↓	ϕ	+13 Gain	−8 Loss	+ 5 No change
EJECTION PROCEDURES						
STUDENT PILOTS (SNAs)						
Experimental	↑	ϕ	↑	+12 Gain	−1 No loss	+11 Net gain
Control	ϕ	ϕ	ϕ	+ 8 No gain	−6 No loss	+ 2 No change
STUDENT NFO (SNFOs)						
Experimental	↑	ϕ	↑	+17 Gain	−2 No loss	+15 Net gain
Control	↑	ϕ	↑	+14 Gain	−4 No loss	+10 Net gain
POST-EGRESS						
STUDENT PILOTS (SNAs)						
Experimental	↑	ϕ	↑	+16 Gain	−5 No loss	+11 Net gain
Control	ϕ	ϕ	ϕ	+7 No gain	−5 No loss	+2 No change
STUDENT NFO (SNFOs)						
Experimental	↑	ϕ	↑	+22 Gain	−5 No loss	+17 Net gain
Control	↑	↓	ϕ	+15 Gain	−17 Loss	−2 No change
EQUIPMENT LOCATION						
STUDENT PILOTS (SNAs)						
Experimental	↑	ϕ	ϕ	+ 8 Gain	−1 No loss	+ 7 No change[c]
Control	ϕ	ϕ	ϕ	+ 2 No gain	+1 No loss	+ 3 No change
STUDENT NFO (SNFOs)						
Experimental	↑	ϕ	↑	+25 Gain	−7 No loss	+18 Net gain
Control	ϕ	ϕ	ϕ	+4 No gain	−1 No loss	+ 3 No change

↑ = statistically significant increase, $p < .05$.
ϕ = no statistical significance indicated, $p \geq .05$.
↓ = statistically significant decrease, $p < .05$.

[a]Terms defined on p. 16

[b]Note that the term "no loss," as used in the Retention column, means no statistically significant loss.

[c]The amount of loss in this case was statistically negligible, but sufficient to negate the gain achieved during the post-test.

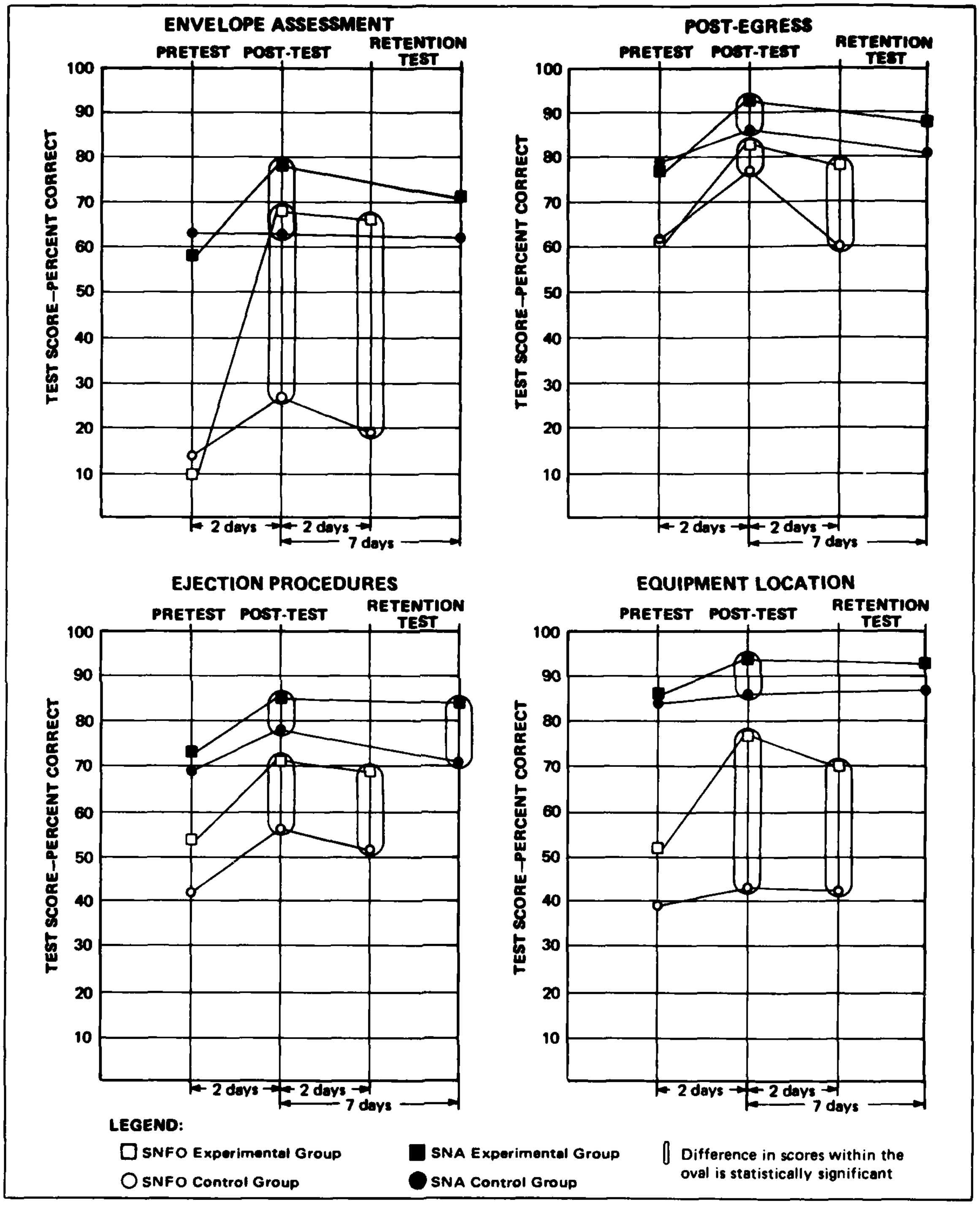

Figure 8. Graphic analysis experimental/control group.

- In all four of the SNFO retention test conditions, the experimental group registered performances greater than those of the control group at levels that were statistically significant. SNA experimental groups also showed superior net information gains in all four content areas, but the differences were statistically significant in only one content area (Procedures). However, an examination of the graphic shows that the trend was for experimental group scores to be superior to those of the control groups.
- In no instance was performance of the control group superior to that of the experimental group.

Simulation Tests

In addition to the paper-and-pencil tests used during the SNFO and SNA evaluations, the SNAs were tested on selected ejection scenarios using the T-2 operational flight trainer (OFT). The simulation exercises were given during the post-test phase of the evaluation. The results (Figure 9) show the superiority of the performance of the experimental group for the fire-on-takeoff scenario. Statistical analysis (see page A-12) showed that the experimental group scored significantly better than the control group. The loss-of-power-in-descent scenario failed to differentiate between the groups.

The performances of the SNA subjects were scored by instructor pilots. The scoring method assigned maximum scores for subject performance that agreed with the "correct" sequence. Scores were lowered as the subject's performance deviated more and more from the correct sequence.

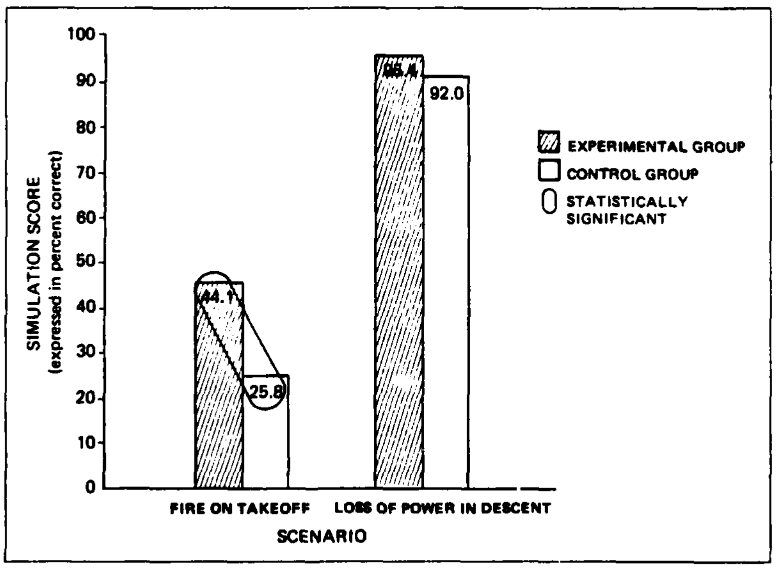

Figure 9. Simulator testing results.

Questionnaire Evaluation

Following all study and testing activities, subjects were asked to complete a fourteen-item questionnaire which requested their opinions on various features of the NATOPS presentations. The questionnaire and the subjects' responses are presented in Appendix E.*

Observations about the questionnaire evaluation are as follows:

- The experimental presentation elicited more favorable comments than did the control presentation.
- The SNFOs (who had not started training) preferred the experimental presentation to a larger extent than did the SNAs (who had finished major parts or all of their training).
- The results of the opinion questionnaire are viewed as positive, tending to reinforce the positive results of the performance-oriented tests.

*Questionnaire responses are not available for approximately half of the SNA control group, nor for three of the SNFO control group.

DISCUSSION

The evaluation results demonstrate that the experimental presentations produced levels of initial learning that were consistently higher than the initial learning produced by conventional presentations. This is especially impressive in view of the time actually spent studying the material (less than two hours) and the informal, uncontrolled study setting (home).

The net information gain of the experimental groups was appreciably greater in all content areas tested than that of the control groups. The retention of the learned information was equivalent for both the experimental and control groups. Thus, the initial learning was responsible for the superior net gains recorded by the experimental group.

In responding to the envelope-assessment questions on the paper-and-pencil test, experimental subjects had the option of relying on either the literal standards (approximation rule) or the conservative standards. Invariably, correct responses to these questions were based on conservative standards; the relatively few attempts to apply the literal standards produced incorrect answers. Thus, the conservative standards were responsible for allowing the experimental subjects to score significantly higher than the control subjects on the paper-and-pencil test of envelope assessment (see pages 16-18 for these test scores, and pages D-3 through D-13 for the two different assessment standards).

The OFT testing indicated that the performance of the experimental group was superior to that of the control group for one of the two emergency scenarios (fire on takeoff). The remaining scenario failed to differentiate between the two groups, with both the experimental and control groups scoring very high. It was later learned that the loss-of-power emergency is practiced repeatedly during training flights, thereby achieving an essentially unimprovable level of performance.

The gains demonstrated by the paper-and-pencil tests in the Envelope Assessment and Ejection Procedures content areas are especially relevant, since these are the aspects of ejection that are most in need of improvement. The gains demonstrated by the SNFOs are promising also, since inexperienced crewmembers are a primary target of this NATOPS manual.

RECOMMENDATIONS

The experimental results of this project show that the new Technical Information presentation procedures employed increase the user's awareness of the ejection-envelope parameters and improve his grasp of the procedures necessary to operate the ejection hardware. It appears reasonable that these improvements can improve crewmembers' performance, and thus increase the survival rate for ejections. Accordingly, it is recommended that steps be taken to make available to the Fleet ejection information prepared in the formats developed in this study.

The introduction of these ejection presentations in the Fleet should consider the following possibilities:

Applications

1. Update the ejection presentations appearing in the NATOPS manual for the T-2 aircraft in accordance with the presentations tested during this project.
2. Develop a specification to guide the preparation of ejection information presentations, applicable to other operational aircraft as well as the T-2.

Additional Research

3. Develop and test similar ejection-information presentations for operational aircraft and experienced crewmembers.
   (a) Cover both the Envelope Assessment and Equipment Operating procedures.
   (b) Consider format modifications, including the areas of rehearsal and proficiency exercises, in order to improve the recallability of the learned information.
   (c) Modify NATOPS manuals of other operational aircraft so as to apply the lessons learned.
4. Develop and test the reformatting methods in other areas where performance improvement is needed. Specifically, consider applying reformatting methods to:
   (a) The descent, landing, survival, and recovery portions of the ejection process.
   (b) Procedures for handling other kinds of emergencies and the interface between an emergency and the ejection decision.
   (c) Development of individualized, low-cost training techniques to help achieve and maintain proficiency in using the "approximation rule" approach to envelope assessment.

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APPENDIX A

STATISTICAL ANALYSIS OF RESULTS

Paper-and-Pencil Tests

Paper-and-pencil tests (presented in Appendix B) were used to detect any learning differences produced by the current and experimental methods of presenting ejection information in the T-2 NATOPS manual.

The paper-and-pencil test data were analyzed by a 2 x 3 Lindquist Type 1[1] repeated measure design (Table A-1). The subsequent multiple range comparisons between the results of each of the test sessions for the content areas were demonstrated through the Tukey[2] tests. This particular test was chosen because it guarantees the alpha level for all comparisons to be no greater than the specified alpha. The *t*-test was used to analyze the differences between the experimental and control groups over the test sessions. In all cases, the .05 level of significance was used. A power analysis was conducted on the significant SNA F-table data in order to verify the analysis.

Table A-1

Experimental Analysis

		Test		
		Pretest	Post-Test	Retention Test
Group	Experimental			
	Control			

The statistical charts and tables produced by this evaluation follow:

- Analyses for SNA results (pp. A-4 through A-7)
- Analyses for SNFO results (pp. A-8 through A-11)
- Simulator Scenarios, SNA Sample Population (p. A-12)

[1,2]Descriptions of the Tukey test and other statistical techniques used in this analysis can be found in:

Dayton, C.M. *The Design of Educational Experiments*. New York: McGraw-Hill Book Co., 1970.

Anastasi, A. *Psychological Testing* (4th edition). New York: McMillan Publishing Co., Inc., 1976.

STUDENT NAVAL AVIATORS

Content Area: Envelope Assessment

F-Table (Lindquist Type 1 2 X 3 repeated measures)

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F-Ratio (Mixed)
Test	2	2,435.84	1,217.92	1.345
Group	1	1,167.27	1,167.27	5.947*
TxG	2	1,810.54	905.27	4.612*
Exp. Error	108	21,199.30	196.29	
Total	113	26,612.95		

Power
Group = .59
TxG = .74

Tukey Test (Within group differences)

Content Area	Group	N	σ_p/N	df	α .01 .05	HSD	$\overline{X}_i - \overline{X}_j \quad i \neq j$
Envelope Assess- ment	Experi- mental	22	3.3478	3, 63	4.28 3.40	14.3286 11.3825	$\overline{X}_{pre} - \overline{X}_{post}$ = −19.409** $\overline{X}_{pre} - \overline{X}_{ret}$ = −12.045* $\overline{X}_{post} - \overline{X}_{ret}$ = 7.363
	Control	16	2.8052	3, 45	4.35 3.43	12.2026 9.6218	$\overline{X}_{pre} - \overline{X}_{post}$ = − 0.1250 $\overline{X}_{pre} - \overline{X}_{ret}$ = 1.3750 $\overline{X}_{post} - \overline{X}_{ret}$ = 1.50

t-Test for Experimental Group vs. Control Group (two tailed)

Content Area:	Pretest	Post-Test	Retention Test
Envelope Assessment	−1.0429	4.2150**	1.7376

*Significant at the .05 level.
**Significant at the .01 level.

STUDENT NAVAL AVIATORS

Content Area: Ejection Procedures

F-Table (Lindquist Type 1 2 X 3 repeated measures)

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F-Ratio (Mixed)
Test	2	2,051.42	1,025.71	5.1822*
Group	1	1,874.09	1,874.09	20.77**
TxG	2	295.86	197.93	2.193
Exp. Error	108	9,744.42	90.23	
Total	113	14,065.79		

Power
Tests = .76
Group = .63

Tukey Test (Within group differences)

Content Area	Group	N	σ_p/N	df	α .01 .05	HSD	$\overline{X}_i - \overline{X}_j$ i ≠ j
Ejection	Experi-mental	22	1.9883	3,63	4.28 3.40	8.5099 6.7602	$\overline{X}_{pre} - \overline{X}_{post}$ = −12.227** $\overline{X}_{pre} - \overline{X}_{ret}$ = −10.864** $\overline{X}_{post} - \overline{X}_{ret}$ = 1.364
Procedures	Control	16	2.4338	3,45	4.35 3.43	10.587 8.3479	$\overline{X}_{pre} - \overline{X}_{post}$ = − 7.3125 $\overline{X}_{pre} - \overline{X}_{ret}$ = − 1.625 $\overline{X}_{post} - \overline{X}_{ret}$ = 5.6875

t-Test for Experimental Group vs. Control Group (two tailed)

Content Area:	Pretest	Post-Test	Retention Test
Ejection Procedures	0.9105	4.9314**	3.6764**

*Significant at the .05 level.
**Significant at the .01 level.

Content Area: Post-Egress

F-Table (Lindquist Type 1 2 X 3 repeated measures)

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F-Ratio (Mixed)
Tests	2	2,749.18	1,374.59	4.7401*
Group	1	318.76	381.76	2.839
TxG	2	579.98	289.99	2.16
Exp. Error	108	14,522.92	134.47	
Total	113	18,233.83		

Power
Tests = .82

Tukey Test (Within group differences)

Content Area	Group	N	σ_p/N	df	α .01 .05	HSD	$\overline{X}_i - \overline{X}_j \quad i \neq j$
Post-	Experi-mental	22	2.5944	3,63	4.35 3.43	11.1040 8.8210	$\overline{X}_{pre} - \overline{X}_{post}$ = −16.1818** $\overline{X}_{pre} - \overline{X}_{ret}$ = −10.091* $\overline{X}_{post} - \overline{X}_{ret}$ = 5.0905
Egress	Control	16	2.6859	3,45	4.28 3.40	11.6837 9.2126	$\overline{X}_{pre} - \overline{X}_{post}$ = 6.1250 $\overline{X}_{pre} - \overline{X}_{ret}$ = 1.8125 $\overline{X}_{post} - \overline{X}_{ret}$ = 4.3125

t-Test for Experimental Group vs. Control Group (two tailed)

Content Area:	Pretest	Post-Test	Retention Test
Post-Egress	−0.7053	4.8233**	1.3225

*Significant at the .05 level.

**Significant at the .01 level.

Content Area: Equipment Location

F-Table (Lindquist Type 1 2 X 3 repeated measures)

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F-Ratio (Mixed)
Test	2	763.28	381.64	4.378*
Group	1	763.19	763.19	6.535*
TxG	2	174.35	87.18	0.7465
Exp. Error	108	12,612.62	116.78	
Total	113	14,313.44		

Power
Tests = .66
Group = .52

Tukey Test (Within group differences)

Content Area	Group	N	σ_p/N	df	α .01 .05	HSD	$\overline{X}_i - \overline{X}_j \quad i \neq j$
Equipment	Experi-mental	22	2.3006	3, 63	4.28 3.40	9.8466 7.8220	$\overline{X}_{pre} - \overline{X}_{post}$ = −8.227* $\overline{X}_{pre} - \overline{X}_{ret}$ = −7.000 $\overline{X}_{post} - \overline{X}_{ret}$ = 1.227
Location	Control	16	2.7072	3, 45	4.35 3.43	11.7763 9.2857	$\overline{X}_{pre} - \overline{X}_{post}$ = −2.25 $\overline{X}_{pre} - \overline{X}_{ret}$ = −2.812 $\overline{X}_{post} - \overline{X}_{ret}$ = −0.563

t-Test for Experimental Group vs. Control Group (two tailed)

Content Area:	Pretest	Post-Test	Retention Test
Equipment Location	0.4370	2.8682**	1.7122

*Significant at the .05 level.
**Significant at the .01 level.

Content Area: Envelope Assessment

F-Table (Lindquist Type 1 2 X 3 repeated measures)

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F-Ratio (Mixed)
Test	2	67,520.61	33,760.30	2.0612
Group	1	50,730.86	50,730.86	240.24**
TxG	2	32,758.29	16,379.14	77.56**
Exp. Error	255	53,848.12	211.1691	
Total	260	204,857.87		

Tukey Test (Within group differences)

Content Area	Group	N	σ_p/N	df	α .01 / .05	HSD	$\bar{X}_i - \bar{X}_j$ $i \neq j$
Envelope Assess-	Experi- mental	45	2.3757	3, 132	4.18 3.35	9.9304 7.9586	$\bar{X}_{pre} - \bar{X}_{post}$ = −57.6** $\bar{X}_{pre} - \bar{X}_{ret}$ = −55.7** $\bar{X}_{post} - \bar{X}_{ret}$ = 1.87
ment	Control	42	1.9835	3, 123	4.20 3.36	8.3307 6.6646	$\bar{X}_{pre} - \bar{X}_{post}$ = −13.5** $\bar{X}_{pre} - \bar{X}_{ret}$ = − 5.36 $\bar{X}_{post} - \bar{X}_{ret}$ = 8.12*

t-Test for Experimental Group vs. Control Group (two tailed)

Content Area:	Pretest	Post-Test	Retention Test
Envelope Assessment	−1.5189	13.9343**	12.2178**

*Significant at the .05 level.
**Significant at the .01 level.

STUDENT NAVAL FLIGHT OFFICERS

Content Area: Ejection Procedures

F-Table (Lindquist Type 1 2 X 3 repeated measures)

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F-Ratio (Mixed)
Test	2	12,334.74	6,167.37	31.785*
Group	1	13,104.18	13,104.178	77.360**
TxG	2	388.07	194.037	1.1455
Exp. Error	255	43,194.76	169.39	
Total	260	69,021.76		

Tukey Test (Within group differences)

Content Area	Group	N	σ_p/N	df	α .01 .05	HSD	$\bar{X}_i - \bar{X}_j \quad i \neq j$
Ejection	Experi-mental	45	2.8547	3,132	4.18 3.35	11.932 9.432	$\bar{X}_{pre} - \bar{X}_{post}$ = −18.2113** $\bar{X}_{pre} - \bar{X}_{ret}$ = −15.482** $\bar{X}_{post} - \bar{X}_{ret}$ = 2.7291
Pro-cedures	Control	42	2.7105	3,123	4.20 3.36	11.3841 9.107	$X_{pre} - X_{post}$ = −13.5445** $X_{pre} - X_{ret}$ = −10.46* $X_{post} - X_{ret}$ = 3.07

t-Test for Experimental Group vs. Control Group (two tailed)

Content Area:	Pretest	Post-Test	Retention Test
Ejection Procedures	1.6960	6.0593**	2.5780*

*Significant at the .05 level.
**Significant at the .01 level.

STUDENT NAVAL FLIGHT OFFICERS

Content Area: Post-Egress

F-Table (Lindquist Type 1 2 X 3 repeated measures)

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F-Ratio (Mixed)
Test	2	15,012.62	7,506.31	3.58
Group	1	4,581.78	4,581.78	19.72**
TxG	2	4,193.47	2,906.74	9.03**
Exp. Error	255	59,237.09	232.30	
Total	260	83,024.97		

Tukey Test (Within group differences)

Content Area	Group	N	σ_p/N	df	α .01 / .05	HSD	$\overline{X}_i - \overline{X}_j \quad i \neq j$
Post-	Experi-mental	45	2.1261	3,132	4.18 3.35	8.8871 7.1224	$\overline{X}_{pre} - \overline{X}_{post}$ = −21.9111** $\overline{X}_{pre} - \overline{X}_{ret}$ = −17.333** $\overline{X}_{post} - \overline{X}_{ret}$ = 4.5778
Egress	Control	42	2.5038	3,123	4.20 3.36	10.5160 8.4128	$\overline{X}_{pre} - \overline{X}_{post}$ = −14.8809** $\overline{X}_{pre} - \overline{X}_{ret}$ = − 2.0714 $\overline{X}_{post} - \overline{X}_{ret}$ = 16.9523**

t-Test for Experimental Group vs. Control Group (two tailed)

Content Area:	Pretest	Post-Test	Retention Test
Post-Egress	−0.1376	3.6986**	4.2911**

**Significant at the .01 level.

STUDENT NAVAL FLIGHT OFFICERS

Content Area: Equipment Location

F-Table (Lindquist Type 1 2 X 3 repeated measures)

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F-Ratio (Mixed)
Test	2	10,374.99	5,187.49	2.1991
Group	1	40,943.38	40,943.38	73.5694**
TxG	2	4,717.82	2,358.91	4.2386*
Exp. Error	255	141,914.37	556.52	
Total	260	197,950.55		

Tukey Test (Within group differences)

Content Area	Group	N	σ_p/N	df	α .01 .05	HSD	$\overline{X}_i - \overline{X}_j$ $i \neq j$
Equipment	Experimental	45	5.0864	3,132	4.18 3.35	21.261 17.0394	$\overline{X}_{pre} - \overline{X}_{post}$ = −25.4047** $\overline{X}_{pre} - \overline{X}_{ret}$ = −18.979* $\overline{X}_{post} - \overline{X}_{ret}$ = 6.4256
Location	Control	42	4.807	3,123	4.20 3.36	20.1894 16.1515	$\overline{X}_{pre} - \overline{X}_{post}$ = −4.4142 $\overline{X}_{pre} - \overline{X}_{ret}$ = −2.6518 $\overline{X}_{post} - \overline{X}_{ret}$ = 1.7565

t-Test for Experimental Group vs. Control Group (two tailed)

Content Area:	Pretest	Post-Test	Retention Test
Equipment Location	0.7671	7.6892**	4.3065**

*Significant at the .05 level.

**Significant at the .01 level.

Simulator Scenarios
SNA Sample Population

t-Test for Experimental vs. Control Group

The performances of the experimental and control SNAs on the OFT scenarios were analyzed through the *t*-test procedure, noted below:

(A) LOSS OF POWER IN DESCENT

Group	N	$\overline{X}$	σ	t
Experimental	22	95.41	7.27	0.97
Control	16	92.0	14.07	

(B) FIRE ON TAKEOFF

Group	N	$\overline{X}$	σ	t
Experimental	22	44.09	26.75	2.34*
Control	16	25.81	18.82	

t-Test for Combined Scenarios

Group	N	$\overline{X}$	σ	t
Experimental	22	69.59	13.62	2.61*
Control	16	58.56	11.70	

*Significant at the .05 level (critical value = 2.03)

APPENDIX B
DEVELOPMENT OF TESTS USED IN STUDY

Paper-and-Pencil Tests

Preliminary paper-and-pencil tests were developed based on an analysis of the performance requirements outlined in the NATOPS manual. The preliminary tests were then given to pilot instructors at NAS Pensacola, who validated the content of the tests and suggested modifications.

Each of the tests (i.e., the pre-, post-, and retention tests) was divided into the four content areas described earlier. The post-test battery was developed first. The pretest and retention tests were split-half versions of this post-test, meaning that random samples were taken from the post-test to form comparable pretests and retention tests. The point totals of each of the tests are presented in Table B-1; weights given to individual test questions appear alongside the questions in the paper-and-pencil tests, presented on pages B-13 to B-38.

Table B-1

Total Possible Points for Paper-and-Pencil Tests

	Pretest	Post-Test	Retention Test
Envelope Assessment (EA)	12 points	25 points	10 points
Ejection Procedure (EP)	10 points	45 points	18 points
Post-Egress (PE)	12 points	25 points	7 points
Equipment Location (EL)	12 points	30 points	10 points

The ratio of points accumulated for correct responses to total points yielded the percentage scores used during the evaluation. The ranges of scores recorded for each group are recorded in Tables B-2 and B-3.

Reliability

When test items possess functional unity, they measure the same content area. The functional unity of the test items developed in this project was measured by computing the internal consistency reliability for each of the content areas. The data collected during the post-test phase of the SNFO evaluation was used for this computation, the results of which are presented below.

Envelope Assessment	$\underline{r} = .85$
Ejection Procedure	$\underline{r} = .76$
Post-Egress	$\underline{r} = .78$
Equipment Location	$\underline{r} = .82$

The reliability coefficients obtained were sufficiently high in each instance to demonstrate the comparability of the questions covering each of the content areas.

Tests

The tests covering the four content areas are included at the end of this Appendix.

Table B-2
Range of Scores for Paper-and-Pencil Tests

Student Naval Flight Officers

	Pretest	Post-Test	Retention Test
Envelope Assessment			
Experimental	0 – 42	31 – 94	11 – 86
Control	0 – 33	7 – 50	0 – 57
Ejection Procedures			
Experimental	20 – 80	53 – 89	37 – 92
Control	10 – 65	30 – 72	21 – 84
Post-Egress			
Experimental	30 – 100	60 – 96	14 – 100
Control	33 – 100	48 – 90	14 – 93
Equipment Location			
Experimental	0 – 84	35 – 100	10 – 100
Control	10 – 77	11 – 76	10 – 100

Note. All scores listed above are fractions of the questions answered correctly, expressed as percentages.

Table B-3
Range of Scores for Paper-and-Pencil Tests

Student Naval Aviators

	Pretest	Post-Test	Retention Test
Envelope Assessment			
Experimental	32 – 100	58 – 100	30 – 100
Control	42 – 75	42 – 80	46 – 91
Ejection Procedures			
Experimental	60 – 100	72 – 94	63 – 100
Control	50 – 100	68 – 85	50 – 95
Post-Egress			
Experimental	28 – 100	83 – 100	57 – 100
Control	65 – 90	76 – 96	57 – 100
Equipment Location			
Experimental	67 – 100	83 – 100	50 – 100
Control	50 – 100	63 – 96	75 – 100

Note. All scores listed above are fractions of the questions answered correctly, expressed as percentages.

Test Validation

Content Validity

When test items possess content validity they are said to measure knowledges critical to the area of concern, in this case, the ejection process. T-2 instructors were asked to review draft questions in order to maximize content validity.

OFT Simulator Tests

The simulation tests included the "loss-of-power" and "fire-on-takeoff" scenarios, both of which required an eventual ejection. The purpose of the OFT tests was to determine what procedures the SNAs initiated at the commencement of the emergency exercise, how they handled the situation throughout, and at what point they initiated the "inevitable" ejection. The SNAs were not aware ahead of time that ejection would ultimately be required.

The ejection scenarios were based on the capabilities programmed into the OFT. The scenarios were developed with the cooperation of pilot instructors at NAS, Meridian, Mississippi.

A checklist of scenario performance options was monitored throughout the testing, with weighted scores assigned to each of the responses. The weighting scheme was developed with the cooperation of pilot instructors. This scheme was based on optimal ejection points identified within the scenarios. Summary outlines of the scenarios are presented in graphic and flow chart form in Figures B-1, B-2 and B-3. A graphic description of the loss-of-power scenario appears as Figure 7 in the main part of this report.

Each of the scenarios was worth a total of 25 points. The scores were then converted into percentages and evaluated accordingly. The range of scores recorded for each scenario is listed in Table B-4.

Table B-4

Range of Scores for OFT Simulation Tests (SNA)

Group	Fire on Takeoff	Loss of Power	$\bar{X}$ Combined
Experimental	17 – 100	83 – 100	50 – 100
Control	17 – 75	50 – 100	54 – 83

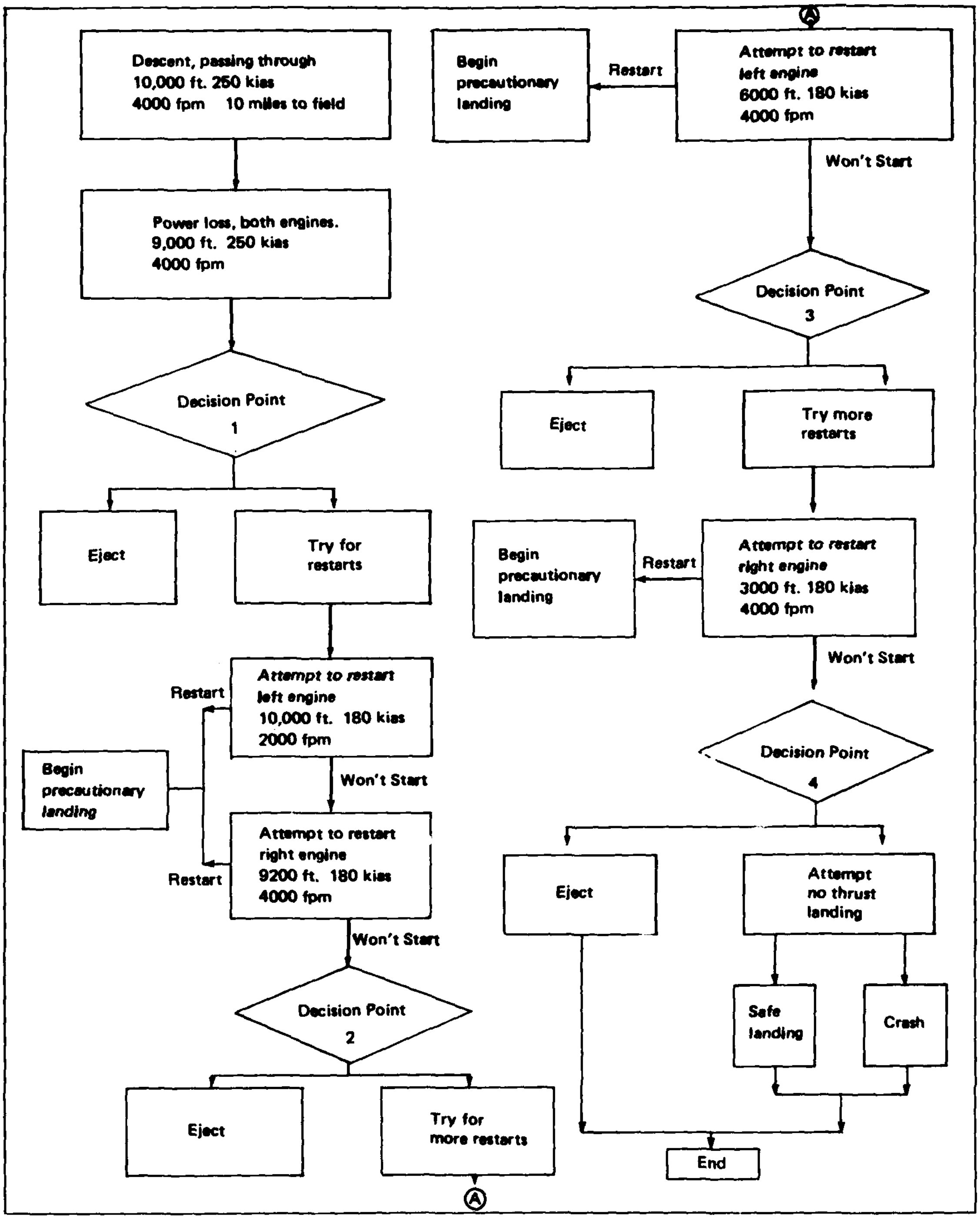


Figure B-1. Loss-of-power flow chart.

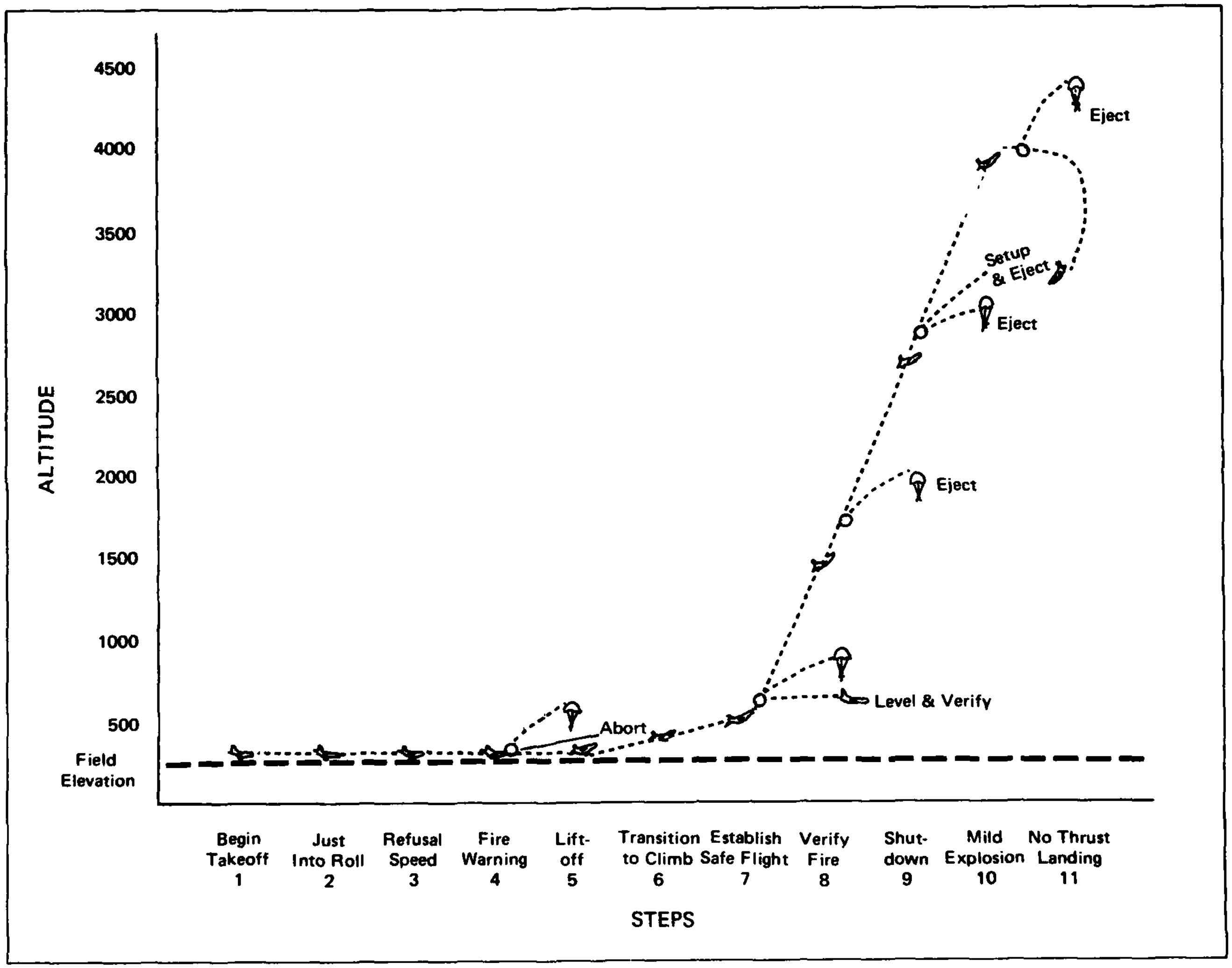


Figure B-2. Fire-on-takeoff scenario.

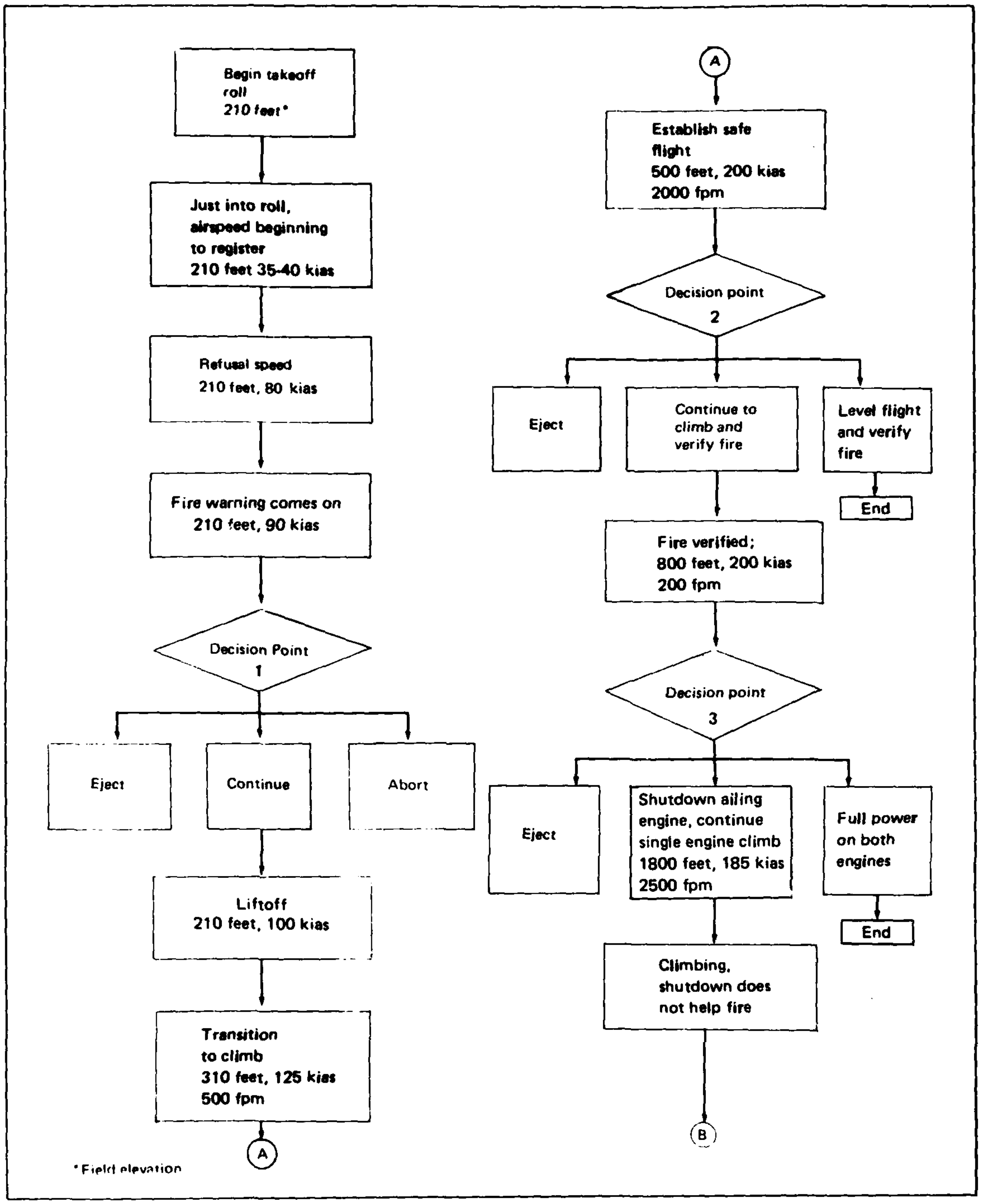


Figure B-3. Fire-on-takeoff flow chart.

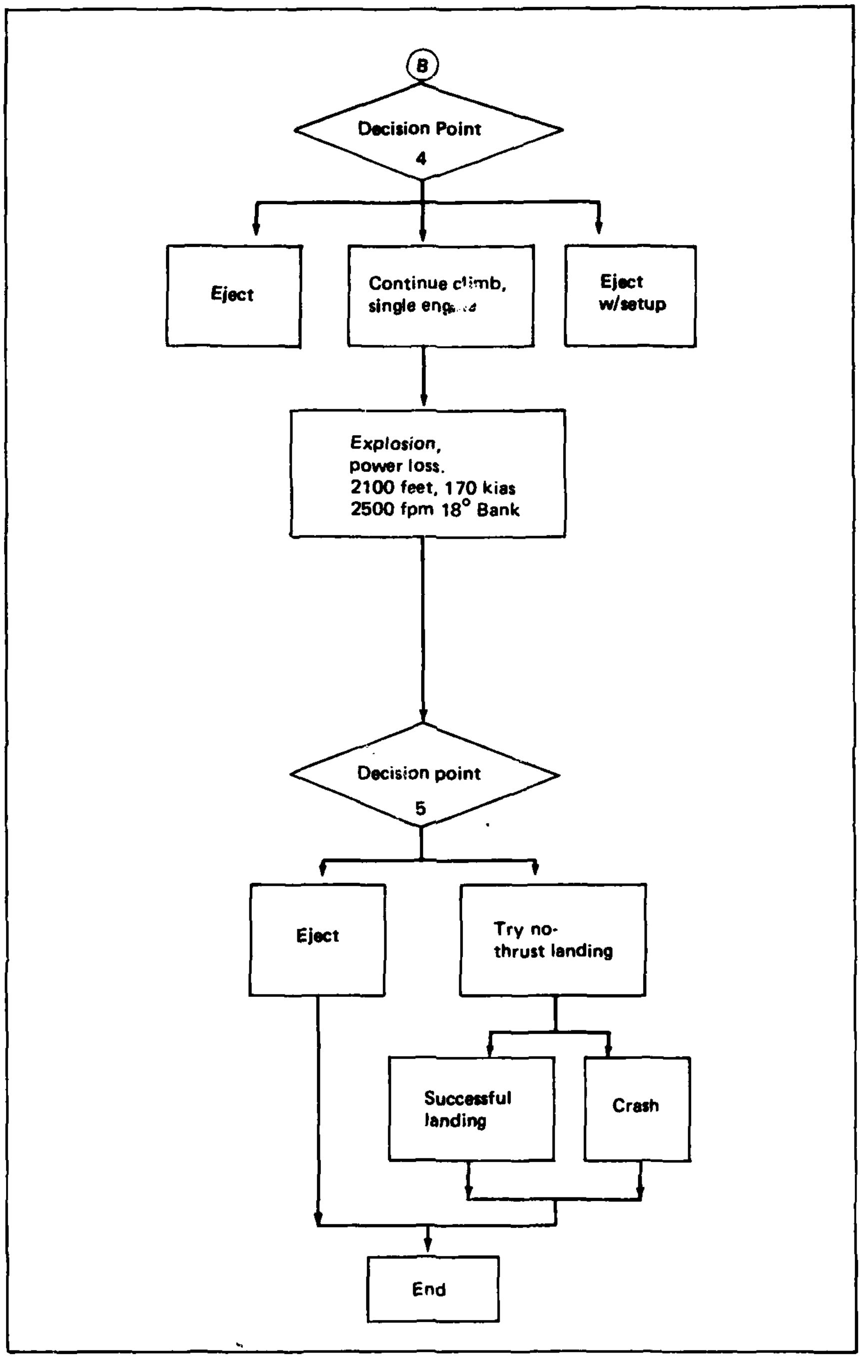


Figure B-3 (*continued*). Fire-on-takeoff flow chart.

PAPER-AND-PENCIL TEST ITEMS

1. Pretest (13 items) (pp. B-13-B-16)
2. Post-test (30 items in four sections) (B-17-B-33)
3. Retention test (8 items) (B-34-B-38)

Items in each test cover all four content areas:

- Envelope Assessment
- Ejection Procedures
- Post-Ejection
- Equipment Location

PRETEST

Instructions

In front of you is a test of short duration. Hypothetical situations and general questions are described in the test. You will be required to respond in a variety of ways to the questions which follow these situations, including: fill in the blanks, yes/no, short essays and picture markups.

You are asked to time yourself for each of the tests by placing the initial starting time on the instruction page and subsequently marking the completion time for the test.

Ex. Start 11:00
Finish 11:10

When you have completed the test, mark the time, and return it to the main desk.

Your cooperation in the taking of this test is very important. The results of these scores will be pooled and analyzed against a separate group receiving different materials.

The individual results of these tests will be treated confidentially and will not be made available to anyone not directly involved with the analysis.

Thank you. Begin.

Starting time: ____________________

Group A - C

Name________________________ Time_______

Service No.____________________ PT

1) Situation: An engine fire required ejection which you initiated at 22,000 feet. The initial ejection events occurred normally and you are now clear of the aircraft but still in the seat. Place an X in the appropriate box.

a) Yes No

1) ___ ___ Always try to "beat the seat" by initiating manual separation

PE* 3 pts. 2) ___ ___ Automatic separation is scheduled to occur at 13,000 feet

3) ___ ___ Manual seat separation requires that you squeeze and pull back and up the Emergency Restraint Release and then roll clear of the seat

b) Automatic separation

Yes No

1) ___ ___ Takes about five seconds

PE 4 pts. 2) ___ ___ Releases restraint system (torso harness)

3) ___ ___ Does everything but get you clear of the seat

4) ___ ___ Cuts curtain cable

2) What alternative remains if a malfunction of your aircraft necessitates ejection and both controls on your seat fail

EP 5 pts. to operate? Explain. ______________________________

____

____

3) Situation: You have initiated ejection. Indicate whether the firing of the initiators does or does not start the following actions.

a) Does Does Not

1) ____ ____ Tighten torso harness

EP 5 pts. 2) ____ ____ Initiate flow of emergency oxygen to face mask

3) ____ ____ Jettison the canopy

4) ____ ____ Eject forward seat first

5) ____ ____ Deploy drogue chute

1

*For explanation of abbreviations, see Table B-1 (pg. B-3).

4) If ejection is necessary below 150 KIAS a second lower limit of _________KIAS is recommended to minimize risk of collision with canopy.

EA 2 pts.

5) You experience power loss at 5000 feet AGL and have sufficient control of the a/c to initiate glide pattern; you should (circle one):

EA 2 pts.

a) eject immediately
b) try one restart
c) try many restarts
d) prepare for no thrust landing

6) Mark the picture to indicate the parts of the body which should be positioned to insure injury-free ejection.
Description:______________________________________

____

____

EL 8 pts.____

____

EL 4 pts.

EA 3 pts. 7) Regardless of the emergency you should initiate ejection by at least __________ feet AGL.

8) Situation: *You lost control of the aircraft at 10,000 feet.* Attempts to regain control have been unsuccessful. Your flight conditions are:

- rate of descent 5000 fpm
- airspeed 350 KIAS
- 60° adverse angle
- dive angle 15°
- altitude 8000 feet.

EA 2 pts. a) Under these conditions the minimum altitude required for safe ejection is __________feet.

EA 3 pts. b) Describe the basis for your response to Question 8 above.____

Place an X next to the appropriate selection for an anticipated parachute landing.

PE 5 pts.

	Yes	No	
9)	___	___	Survival kit serves as protection in tree landings
10)	___	___	Release koch fittings just before contact
11)	___	___	Look down to ground or water so that you can anticipate contact
12)	___	___	Place hands on koch fittings as ground contact nears
13)	___	___	Bend knees slightly and keep feet together

POST-TEST

Instructions

In front of you is a battery of four separate tests of short duration. Hypothetical situations and general questions will be described in the test booklets. You will then be required to respond in a variety of ways to the questions which follow these situations, including: fill in the blanks, yes/no, short essays and picture markups.

You are asked to time yourself for each of the tests by placing the initial starting time on the instruction page and subsequently marking the completion time for each test.

Ex. Start 11:00
Test 1 finish 11:10
Test 2 finish 11:25
Test 3 finish 11:30
Test 4 finish 12:15

When you have completed a test, mark the time and go on to the next test. When you have completed the test, return it to the main desk.

Your cooperation in the taking of this test is very important. The results of these scores will be pooled and analyzed against a separate group receiving different materials.

The individual results of these tests will be treated confidentially and will not be made available to anyone not directly involved with the analysis.

Thank you. Begin.

Starting time: ____________________

Group A - B

Name ______________________ Time _______

Service No. ________________ Envelope Assessment*

Test Section I

1) Situation: You lost control of the aircraft at 10,000 feet. Attempts to regain control have been unsuccessful. Your flight conditions are:

- Rate of descent 5000 fpm
- Airspeed 350 KIAS
- 60° Adverse Angle
- Dive Angle 15°
- Altitude 8000 feet

2 pts. a) Under these conditions the minimum altitude required for safe ejection is _______ feet.

3 pts. b) Describe the basis for your response to Question 1 above. ______________________________________

____

____

____

____

2) Situation: You are at a cruise altitude of 21,000 feet over water and approaching land. Your fuel supply is so low that you don't think you will be able to make land. You are considering ejection.

2 pts. a) What airspeed range would you try to establish for ejecting under these conditions?
________________ to ______________________KIAS

2 pts. b) What altitude would you consider for initiating ejection under these conditions?
__________________________________ feet AGL

1

*EA.

2 pts. 3) a) Does the Adverse Angle add to/decrease/or not affect (circle one) the altitude required for safe ejection?

b) How do you decide whether dive angle or rate of descent determines a safe ejection altitude?

2 pts. ____

____

____

____

____

2 pts. 4) Regardless of the emergency you should initiate ejection by at least _______ feet AGL.

2 pts. 5) What is the minimum altitude required for full ejection seat operation when your rate of descent is 3000 fpm and the aircraft is in a 30° bank? _______________

2 pts. 6) You are flying at 17,000 feet AGL, 240 KIAS and you lose control of the aircraft. At what altitude should you initiate ejection? _________ ft AGL.

7) You experience power loss at 5000 feet AGL and have sufficient control of the a/c to initiate glide pattern, you should (circle one)

2 pts.

a) eject immediately
b) try one restart
c) try many restarts
d) prepare for no thrust landing

Eliminated 8) What airspeed range optimizes pilot chances of surviving ejection?

a) _______ to b) _______ KIAS

2 pts. 9) Bailout is preferable to ditching. T F

2 pts. 10) If ejection is necessary below 150 KIAS a second lower limit of _____ KIAS is recommended to minimize risk of collision w/ canopy.

3

Group A - C

Name ______________________________ Time _______

Service No. ______________________ Ejection Procedures*

Test Section II.

1) Situation: You experience a double flame out while cruising 30 miles S. of Escambia at 285 KIAS and 18,000 feet. You set up "no power" glide but attempted restarts are unsuccessful.

a) Describe the procedures you would initiate to transmit emergency communications.

5 pts.

1) ____

2) ____

3) ____

4) ____

5) ____

b) Write out the content of the message you would transmit.

5 pts.

1) ____

2) ____

3) ____

4) ____

5) ____

*EP.

2) Situation: You have decided to eject because the aircraft is out of control and diving at a high rate of speed. You have elected to use the face curtain to initiate ejection.

a) Describe the arm and hand positions you will assume while initiating ejection.

4 pts.

1) ____________________

2) ____________________

3) ____________________

4) ____________________

Eliminated 5) ____________________

3) Situation: You have initiated ejection. Indicate whether the firing of the initiators does or does not start the following actions.

5 pts.

a)	Does	Does Not	
1)	____	____	Tighten torso harness
2)	____	____	Initiate flow of emergency oxygen to face mask
3)	____	____	Jettison the canopy
4)	____	____	Eject forward seat first
5)	____	____	Deploy drogue chute

b) Do the events you indicated above occur regardless of whether you use the curtain or the LEH?

1 pt. Yes ____________ No ____________

4) Situation: You initiated ejection with the face curtain handle. None of the automatic ejection events occurred.

a) Before trying again you should (check the box(es) next to the appropriate action)

3 pts.

	Yes	No	
1)	___	___	Check position of Command Selector Control
2)	___	___	Check that the Command Selector Control is in Both Eject position
3)	___	___	If in the rear cockpit, move Command Selector Control to Rear Only position

b) After a first ejection attempt with the face curtain handle you are trying again to initiate ejection. You would;

2 pts.

	Yes	No	
1)	___	___	Use one hand on LEH
2)	___	___	Retain your grasp on the face curtain handle
3)	___	___	Use either handle, just make sure the Command Selector Control is in the proper position

c) A second attempt to eject fails to fire initiators. You choose bailout over ditching because of terrain considerations.

3 pts.

	Yes	No	
1)	___	___	Bailout is an accepted technique for abandoning the T-2
2)	___	___	Airspeed for bailout should be lower than for ejection to allow you to get out of the cockpit
Eliminated 3)	___	___	A 250 KIAS is recommended for bail-out
Eliminated 4)	___	___	A 150 KIAS is recommended for bail-out
5)	___	___	Release the restraint system prior to rolling to the inverted position

3

5 pts. 5) What alternative remains if a malfunction of your aircraft necessitates ejection and both controls on your seat fail to operate? Explain.

____

____

____

2 pts. 6) What type ejection seat is installed in the T-2B/T-2C?
__________________ and/or __________________

2 pts. 7) What is the time delay between the forward and aft seat ejections? __________________________________

2 pts. 8) If in front cockpit and the ejection selector is in the aft position and the forward face curtain is pulled, what will occur? ______________________________________

____

____

4 pts. 9) Give a brief description of the ejection sequence.

____

____

____

2 pts. 10) At what altitude does seat/man separation occur?

____

I

Name ______________________________ Group A - C

Service No. ______________________ Time ________

Post Ejection*

Test Section 3.

1) Situation: An engine fire required ejection which you initiated at 18,000 feet. The initial ejection events occurred normally and you are now clear of the aircraft but still in the seat.
Place an X in the appropriate box.

3 pts.

a)	Yes	No	
1)	___	___	Always try to "beat the seat" by initiating manual separation
2)	___	___	Automatic separation is scheduled to occur at 13,000 feet
3)	___	___	Manual seat separation requires that you squeeze and pull back and up the Emergency Restraint Release and then roll clear of the seat

b) Automatic separation

4 pts.

	Yes	No	
1)	___	___	takes about five seconds
2)	___	___	releases restraint system (torso harness)
3)	___	___	does everything but get you clear of the seat
4)	___	___	cuts curtain cable

*PE.

2) Situation: You found it necessary to initiate ejection at 18,000 feet. All events occurred normally so far and after some free fall, you have experienced automatic seat separation.
Use an X to mark the appropriate selection for this situation.

	Yes	No	
1)	___	___	Automatic chute opening should occur at 10,000 feet, or within one second if ejection was initiated below 10,000 feet.
2)	___	___	You must always initiate chute opening manually
3)	___	___	Parachute ripcord is available as a manual backup to automatic chute operation
4)	___	___	Parachute ripcord is pulled with your left hand

4 pts.

3) Describe the desired body positions prior to chute opening.

1) ____

2) ____

3) ____

4) ____

4 pts.

2

4) Situation: After a "by-the-numbers" ejection you are descending in your chute passing through 5000 feet. Place an X next to the appropriate selection for an anticipated landing.

10 pts.

	Yes	No	
1)	___	___	Your actions prior to contact with the surface are the same whether landing over land or water
2)	___	___	Always release the life raft prior to landing
3)	___	___	Oxygen mask and hose are always removed/pulled away
4)	___	___	Life preserver inflation lanyards are actuated by a squeezing action
5)	___	___	Crossing arms to opposite risers is recommended as a protection during tree landing
6)	___	___	Survival kit serves as protection in tree landings
7)	___	___	Release koch fittings just before contact
8)	___	___	Look down to ground or water so that you can anticipate contact
9)	___	___	Place hands on Koch fittings as ground contact nears
10)	___	___	Bend knees slightly and keep feet together

Group A -C

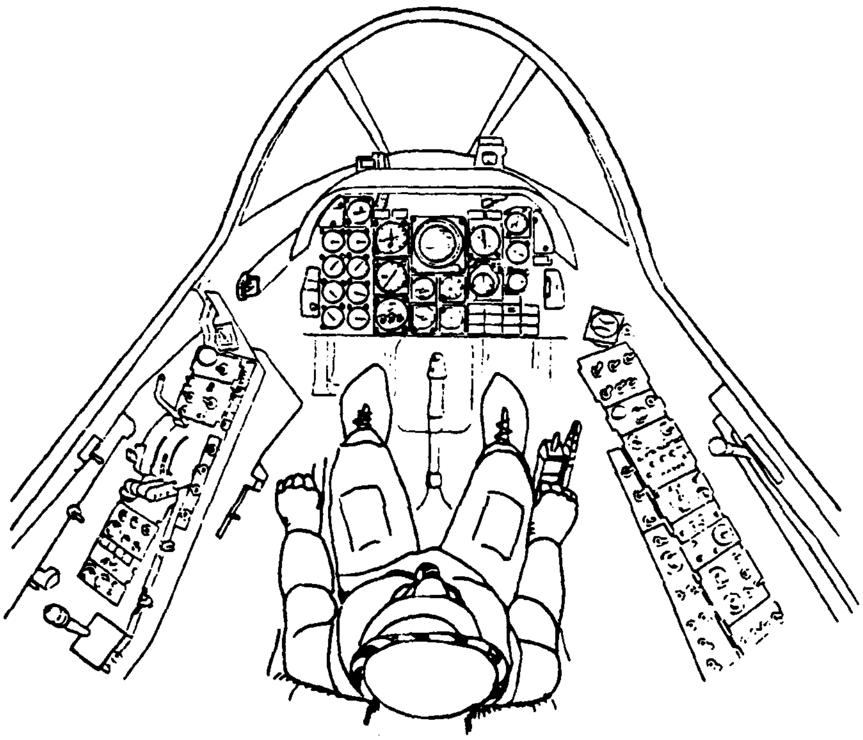
Name ____________________ Time ______

Service No. ________________ Equipment Location*

Test Section 4.

1) Situation: You experience a double flame out at 270 KIAS and 16,000 feet. You set up "no power" glide but attempted restarts are unsuccessful.

6 pts. Mark the cockpit diagram below to indicate how you would set up your equipment to transmit emergency communications.



1

*EL.

2) Mark the picture to indicate the parts of the body which should be positioned to insure injury-free ejection.

Description: ______________________________

____

6 pts.

____

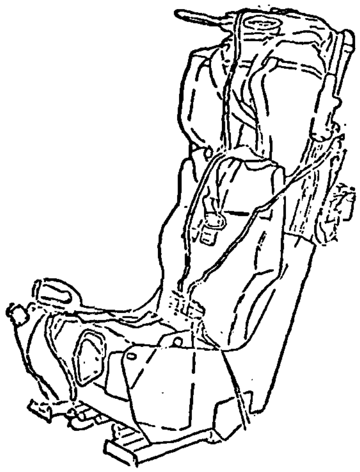
____

____

2

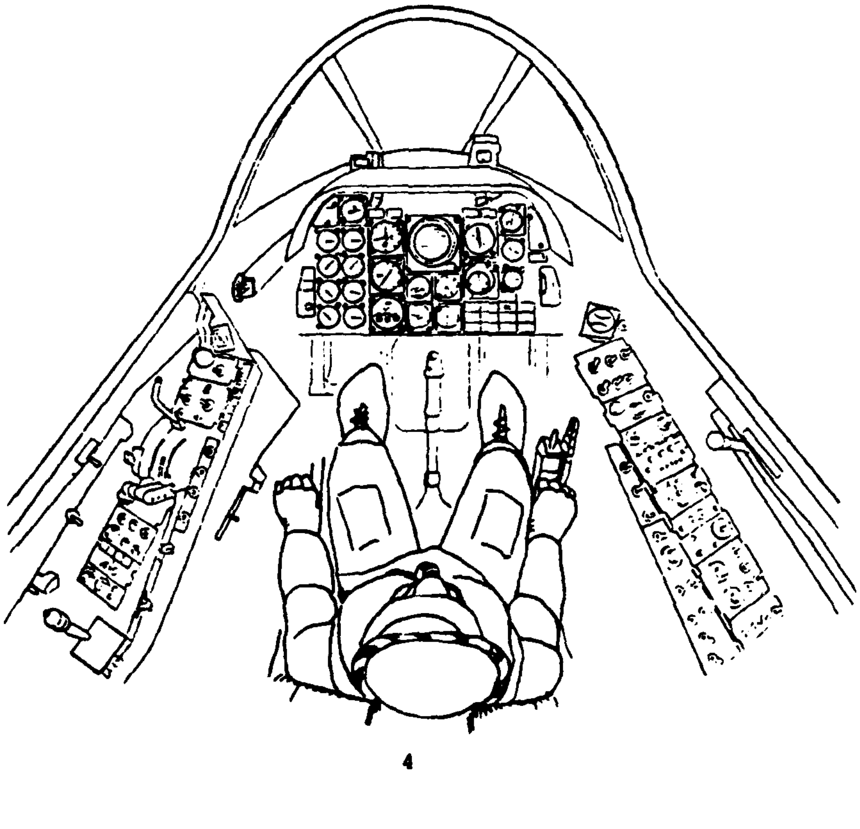
4 pts.

3) Situation: You experienced a "cold cat shot" during carrier launch. It requires immediate ejection. Mark the diagram to indicate preferred control for ejection under this circumstance. Why?



4) Where appropriate, mark the diagram to indicate the steps you would take for a bailout sequence.

6 pts.



4

5. Locate:

(a) Canopy locks

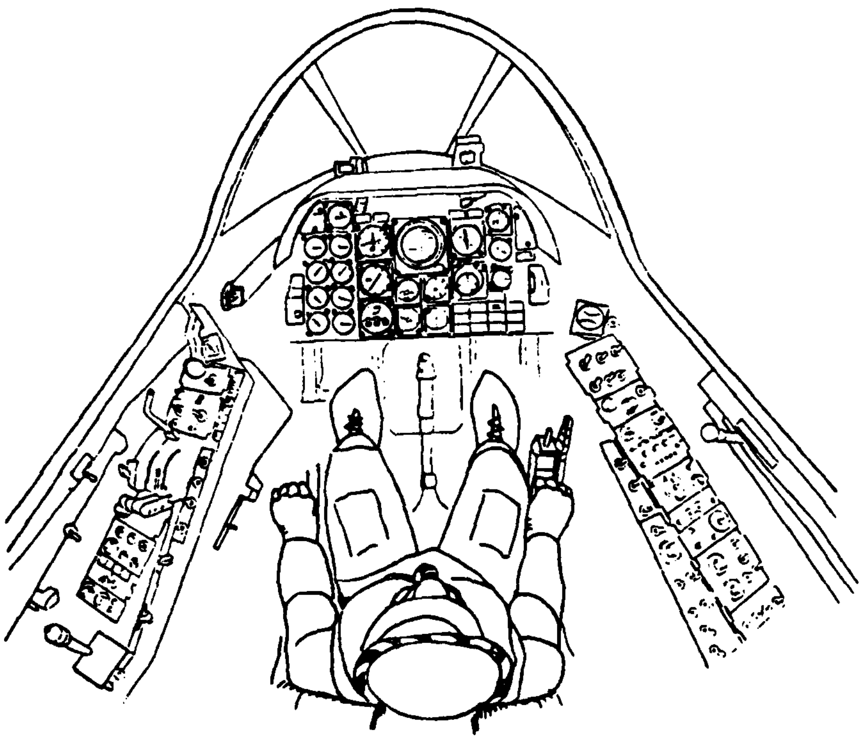
(b) Emergency canopy release handle

(c) Emergency restraint release

(d) Command selector handle

(1) Is it in "Both Eject" position? (circle one) yes no

5 pts.



5

6. Mark the personal equipment you would check prior to initiating ejection.

3 pts.

6

RETENTION TEST

Instructions

In front of you is a test of short duration. Hypothetical situations and general questions are described in the test. You will be required to respond in a variety of ways to the questions which follow these situations, including: fill in the blanks, yes/no, short essays and picture markups.

You are asked to time yourself for each of the tests by placing the initial starting time on the instruction page and subsequently marking the completion time for the test.

Ex. Start 11:00
Finish 11:10

When you have completed the test, mark the time, and return it to the main desk.

Your cooperation in the taking of this test is very important. The results of these scores will be pooled and analyzed against a separate group receiving different materials.

The individual results of these tests will be treated confidentially and will not be made available to anyone not directly involved with the analysis.

Thank you. Begin.

Starting time: ______________________

Group A - C

Name____________________ Time ______

Service No.____________________ RT

1) Situation: You experience a double flame out while cruising 45 miles N. of Estonia at 285 KIAS and 18,000 feet. You set up "no power" glide but attempted restarts are unsuccessful.

EP 5 pts. (a) Describe the procedures you would initiate to transmit emergency communications.

1) ____________________
2) ____________________
3) ____________________
4) ____________________
5) ____________________

(b) Write out the content of the message you would transmit.

1) ____________________
2) ____________________
EP 5 pts. 3) ____________________
4) ____________________
5) ____________________

2) What airspeed range optimizes pilot chances of surviving ejection?

EA 2 pts. a) __________ to b) __________KIAS

3) Situation: You initiated ejection with the face curtain handle. None of the automatic ejection events occurred.

a) Before trying again you should (check the box(es) next to the appropriate action)

	Yes	No	
1)	___	___	Check position of Command Selector Control
2)	___	___	Check that the Command Selector Control is in Both Eject position
3)	___	___	If in the rear cockpit, move Command Selector Control to Rear Only position

EP 3 pts.

1

b) After a first ejection attempt with the face curtain handle you are trying again to initiate ejection. You would:

		Yes	No	
EP 2 pts.	1)	___	___	Use one hand on LEH
	2)	___	___	Retain your grasp on the face curtain handle
	3)	___	___	Use either handle, just make sure the Command Selector Control is in the proper position

c) A second attempt to eject fails to fire initiators. You choose bailout over ditching because of terrain considerations.

		Yes	No	
EP 2 pts.	1)	___	___	Bailout is an accepted technique for abandoning the T-2
	2)	___	___	Airspeed for bailout should be lower than for ejection to allow you to get out of the cockpit
EA 2 pts.	3)	___	___	A 250 KIAS is recommended for bailout
	4)	___	___	A 175 KIAS is recommended for bailout
EP 1 pt.	5)	___	___	Release the restraint system prior to rolling to the inverted position

4) Locate:

(a) Canopy locks

(b) Emergency canopy release handle

(c) Emergency restraint release

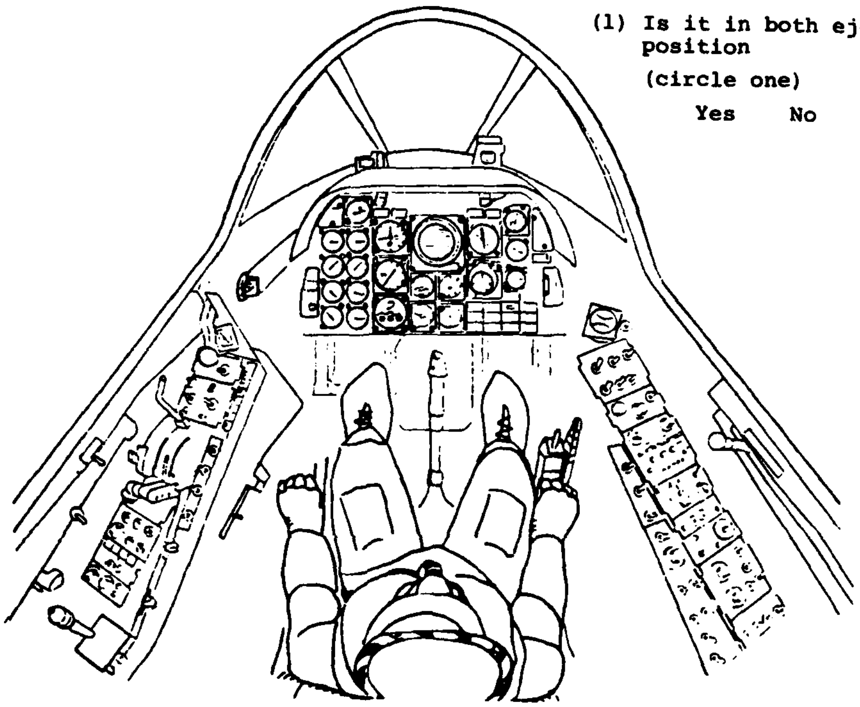
(d) Command selector handle

(1) Is it in both eject position

(circle one)

Yes No

EL 10 pts.



EA 2 pts.

5) What is the minimum altitude required for full ejection seat operation when your rate of descent is 2000 fpm and the aircraft is in a 15° bank?________________________

EA 2 pts.

6) Situation: You are at a cruise altitude of 18,000 feet over water and approaching land. Your fuel supply is so low that you don't think you will be able to make land. You are considering ejection.

a) What airspeed range would you try to establish for ejecting under these conditions?

________________ to __________________KIAS

EA 2 pts.

b) What altitude would you consider for initiating ejection under these conditions? ________________ feet AGL

7) Situation: After a "by-the-numbers" ejection you are descending in your chute passing through 5000 feet. Place an X next to the appropriate selection for an anticipated landing.

PE 3 pts.

	Yes	No	
1)	___	___	Your actions prior to contact with the surface are the same whether landing over land or water
2)	___	___	Always release the life raft prior to landing
3)	___	___	Oxygen mask and hose are always removed/pulled away

8) Describe the desired body position upon ejection after seat/man separation has occurred and prior to the chute opening.

PE 4 pts.

____

____

____

APPENDIX C

EJECTION SECTION
OF NATOPS MANUAL FOR T-2 AIRCRAFT

– UNMODIFIED VERSION –

EJECTION

The decision to abandon the aircraft rests with the pilot in command. It should be made before sink rate and altitude conditions jeopardize safe ejection for both occupants. The aircraft should be abandoned by means of the ejection seat. See figures 5-3 and 5-4. For ejection procedures, see figure 5-5.

Prior to ejecting from a flyable or controllable aircraft, it is the pilot's responsibility to do everything reasonable to ensure that his abandoned aircraft will inflict the least possible damage on impact.

If the canopy fails to jettison, seat ejection will continue with the seats breaking through the canopy. If separation from the seat has not occurred when below 13,000 feet, the occupant should actuate his harness release handle and roll clear of the seat. Parachute opening is automatic.

On aircraft 159721 and subsequent and aircraft having AFC 172, improved safe ejection capability is reflected in figure 5-4A. These graphs do not include reaction time of the pilot initiating ejection, since the effect of time on *minimum safe escape altitude varies with the condition of* flight. Adequate reaction allowance must be made in selecting the decision altitude for initiating ejection. The safe escape requirement for 75 knots airspeed can be disregarded if canopies are jettisoned previously, when time permits.

FAILURE OF SEAT TO EJECT

If the escape system fails to function after pulling the face curtain and the "D" handle to the *full extent*, use the following procedure:

1. Warn other crewman.
2. Jettison the canopy.
3. Pull emergency oxygen ring.
4. If control of the aircraft is still maintained, trim for full nose down, pull stick back to slow aircraft and invert.
5. Harness release handle—Squeeze/PULL aft.
6. Free fall to safe altitude and DEPLOY PARACHUTE MANUALLY BY PULLING "D" RING.
7. Remove oxygen mask after parachute deployment.

Note

In all cases of ejection or bailout over water, inflate MK-3C life vest prior to water entry.

CANOPY JETTISON

In the event it becomes necessary to jettison the canopy, proceed as follows:

1. Canopy emergency release handle—PULL.

WARNING

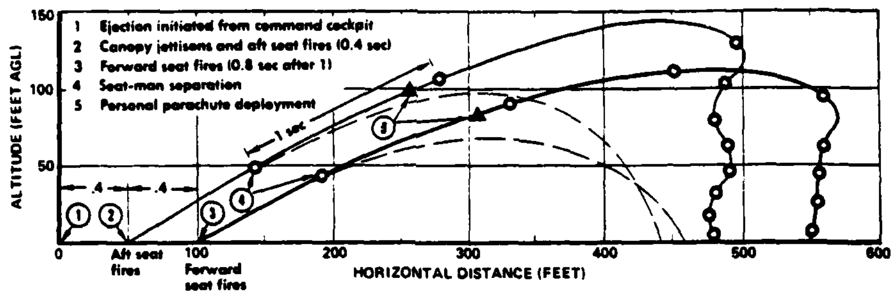
The canopy may not jettison if it is not fully closed.

T-2B/C GROUND LEVEL EJECTION TRAJECTORIES

LS-1 EJECTION SEATS

- Aircraft prior to 159721 not having AFC 172
- Based on 75 knots at ejection

O One-second time increment
—— 200-pound man trajectory
—— 130-pound man trajectory
— — Seat trajectory

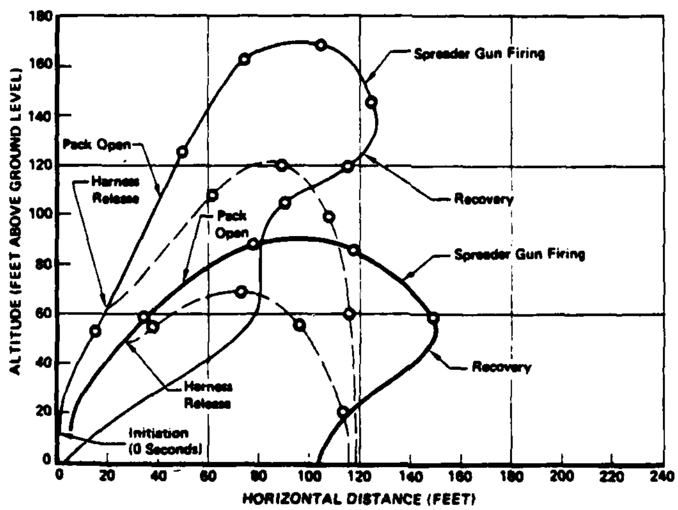


At ground level, safe ejection can be accomplished as long as the level flight airspeed at the time of ejection initiation is 75 knots or greater. However, an altitude of 500 feet is recommended, if at all possible.

LS-1A EJECTION SEATS

- Aircraft 159721 and subsequent and aircraft having AFC 172

O One-second time increment
—— 200-pound man (FWD SEAT)
—— 130-pound man (AFT SEAT)
— — Seat trajectory



Note:

Data typical for zero airspeed at ejection; however, safe ejection requires 75 knots airspeed (or previous manual jettison of canopies) to avoid potential interference during canopy jettison.

Figure 1

AIRCRAFT IN DISTRESS

Any time that a pilot is in distress, he will:

1. Transmit his identification followed by MAYDAY three times on emergency guard channel.
2. Turn IFF/SIF to emergency.
3. Transmit on guard channel the following information as time permits:
   (a) Identification.
   (b) Position (geographical or bearing and distance from a fixed point).
   (c) Altitude.
   (d) Nature of emergency.
   (e) Intended actions.
4. Remain on guard channel for assistance.
5. If emergency situation is corrected, notify all stations on guard channel.

DOWNED AIRCRAFT

ASSISTING AIRCRAFT

The pilots of other aircraft will maintain radio silence while the emergency is in progress, unless assistance or instructions are requested.

First Aircraft

The first aircraft to arrive over the scene of a crash will assume communications command.

1. Orbit the scene at sufficient altitude to ensure effective communications command.
2. Turn on IFF/SIF to emergency.
3. Utilize TACAN and ARR-40 to assist SAR aircraft in reaching the scene.
4. Set power for maximum endurance and remain on station until relieved or until fuel state dictates departure.

Second Aircraft

The second aircraft to arrive at the scene will take station at a low enough altitude to obtain the following information.

1. Condition of the aircraft.
2. Condition of the crew.

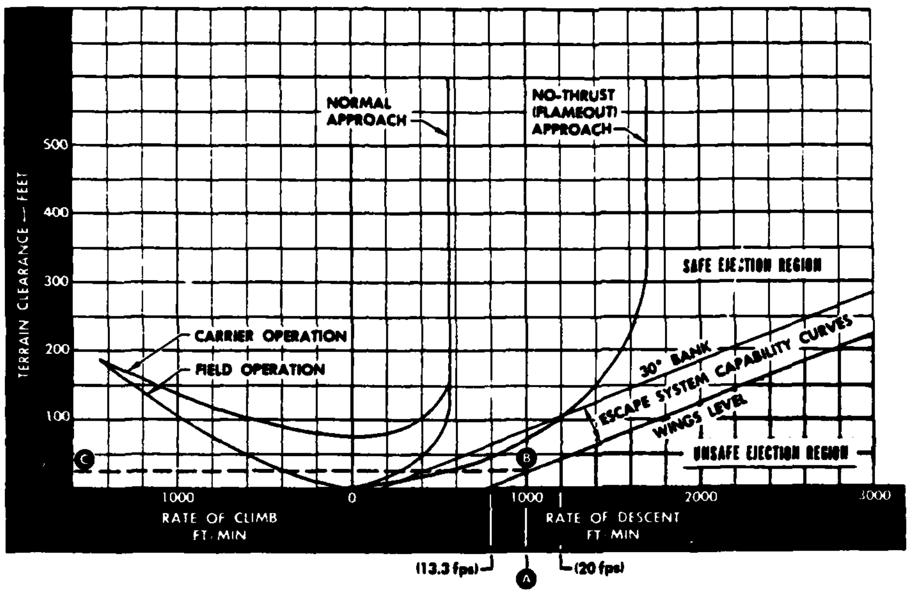
Other Aircraft

If only one aircraft is present at the scene, the pilot will make the low altitude survey, then climb to altitude and follow communications procedures assigned first aircraft.

Other aircraft will remain clear unless assistance is requested.

MINIMUM SAFE EJECTION ALTITUDES

• LS-1 SEAT (AIRCRAFT PRIOR TO 158721 NOT HAVING AFC 172)



Notes:

1. Information presented assumes that the aircraft is under control until seats leave the airplane.
2. For 90° bank add 250 feet to terrain clearance required for wings level.
3. For inverted flight, add 500 feet to terrain clearance required for wings level.
4. Escape system capability curves include:
   a. The data for the curves plotted are based on a 95 percentile man ejecting from the front cockpit and includes a two second reaction time by the crewman. The two second reaction time allowance means that sufficient altitude and time has been incorporated into the curves to provide for parachute deployment. Therefore, for a given point on the minimum safe ejection curve, if the crewman initiates the seat system within two seconds, he will be recovered.
   b. Minimum safe ejection altitude for the escape system capability curves is defined as complete parachute inflation just prior to ground contact for the 95 percentile pilot ejecting from the front cockpit.
   c. Normal aircraft pitch for conditions shown is ±15°.
5. Curves labeled "Normal Approach", "No Thrust (Flameout) Approach", "Field Operation" and "Carrier Operation", are typical curves shown for reference only. Do not use them to read height for safe ejection. The approach and climb curves relate to the aircraft characteristics and indicate that the flight paths are in the safe ejection region of escape system capability curves for wings level and for much of the flight path at 30° bank.

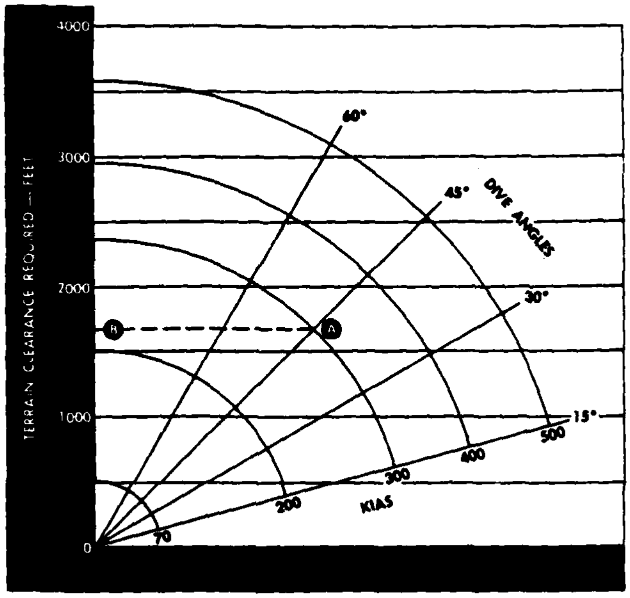
Example:

To determine minimum safe ejection altitude for conditions of 1000 fpm (16.7 fps) rate of descent, aircraft wings level, nose attitude ±15° first enter the chart at Point A. Point A intersects the wings level curve at Point B, which defines the altitude at Point C, approximately 25 feet. A 95 percentile pilot in the front cockpit initiating his seat system within two seconds under the described conditions would be recovered (assuming surface contact in landing configuration with 75 knots airspeed.)

Figure 2

MINIMUM SAFE EJECTION ALTITUDES

● LS-1 SEAT (AIRCRAFT PRIOR TO-158721 NOT HAVING AFC 172)



Notes:

1. Curves are based on a 95 percentile man ejecting from the front cockpit and includes a two second reaction time to initiate seat system.
2. Curves are based on wings level dive attitude and appropriate angle of attack.
3. Minimum safe ejection altitudes for the curves depicted are defined as full inflation of the parachute obtained prior to ground contact for a 95 percentile crewman ejecting from the front cockpit of the airplane.

Example:

The aircraft is at a 45 degree dive angle, wings level at an airspeed of 300 KIAS (point A), point B indicates an altitude of approximately 1700 feet. Providing the 95 percentile man in the front cockpit initiates the seat system within two seconds after reaching this point, his parachute will be inflated just prior to ground contact.

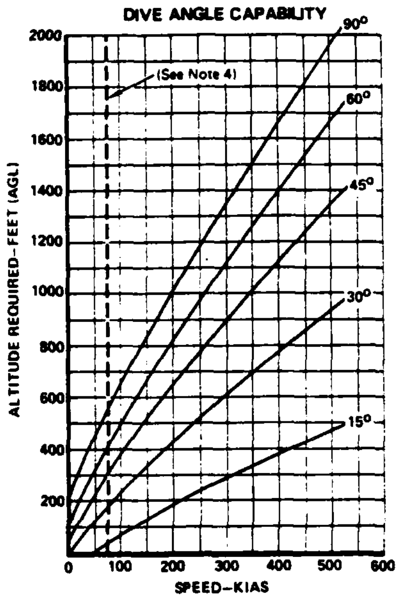
Figure 3

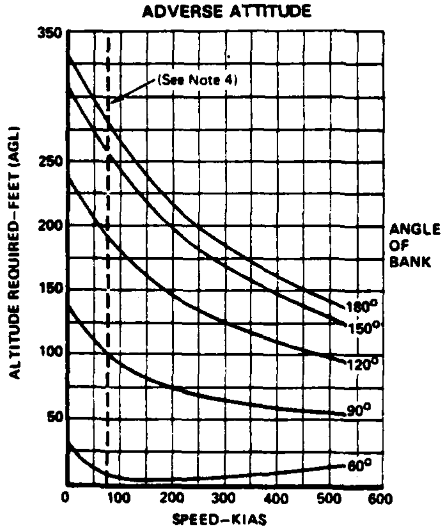
MINIMUM SAFE EJECTION ALTITUDES

- LS-1A EJECTION SEAT (AIRCRAFT 159721 AND SUBSEQUENT AND AIRCRAFT HAVING AFC 172)
- 95 PERCENTILE CREWMAN (TYPICAL UNCLOTHED WEIGHT–200 LBS)
- DATA APPLICABLE FOR FRONT SEAT (LAST MAN OUT) ZERO REACTION TIME

NOTES:

1. Minimum safe escape conditions are those resulting in full inflation of the parachute just prior to ground contact.
2. Dive angle data is based on wings-level attitude and appropriate angle of attack. Applicable roll angle (adverse attitude) data must be added to dive angle or rate of descent altitude requirements.
3. Examples:
   - A 45-degree dive angle at 300 KIAS requires 900 feet *above ground level for safe escape with zero delay.*
   - At 250 KIAS, a 4000-foot-per-minute rate of descent requires 118 feet AGL for safe escape with zero delay and wings level; a 90-degree bank adds 69 feet AGL to the required altitude for a total of 187 feet.
   - At 100 KIAS, no-thrust approach rate of descent (1700 feet per minute or 28.33 feet per second), wings level, approximately 30 feet AGL is required for safe escape with zero delay. If a 2-second delay is encountered, the altitude requirement would increase by 57 feet (87 feet total). If a 60-degree bank is involved at the time of ejection, an additional 5 feet (92 feet AGL) is required.
4. Safe escape requires a minimum of 75 knots airspeed to avoid potential *interference* during canopy jettison. Prior manual jettisoning of canopies allows safe escape at zero airspeed.





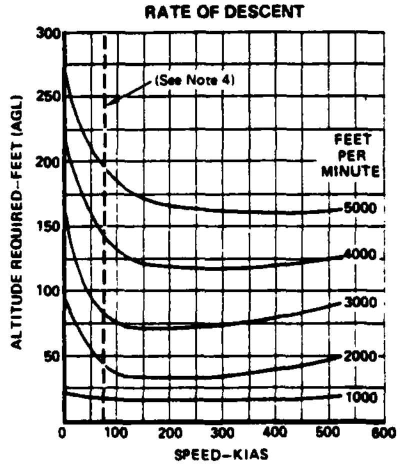
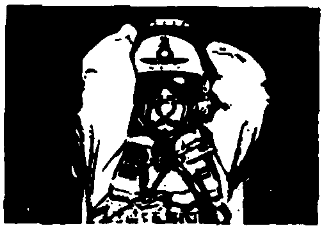


Figure 4

EJECTION

1. CHECK COMMAND COCKPIT EJECTION SELECTOR — *BOTH EJECT.*
2. IF TIME PERMITS WARN CREWMAN AND FOLLOW RADIO DISTRESS PROCEDURE.
3. LEVEL WINGS AND MINIMIZE RATE OF DESCENT
4. POSITION FOR EJECTION; BACK STRAIGHT, CHIN UP, AND BALLS OF FEET ON RUDDER PEDALS.
5. TO EJECT:

PULL FACE CURTAIN **OR** PULL D-RING



The D-ring should be used during low altitude and/or low airspeed situation requiring an expeditious ejection.

> If the ejection attempt fails using one firing control, check that ejection selector handle is correctly positioned and use other firing control. Should both controls fail on one seat, command control can be assumed in the other *cockpit. Dual ejection can then be initiated by positioning ejection control in* the command cockpit to BOTH EJECT and using either firing control.

WHEN SEAT INITIATORS FIRE:

(a) Canopy jettisons.
(b) Inertia reel retracts shoulder harness.
(c) Aft seat ejects followed by forward seat.
(d) Emergency oxygen is activated.
(e) Drogue chute deploys and separation aneroid system is armed.

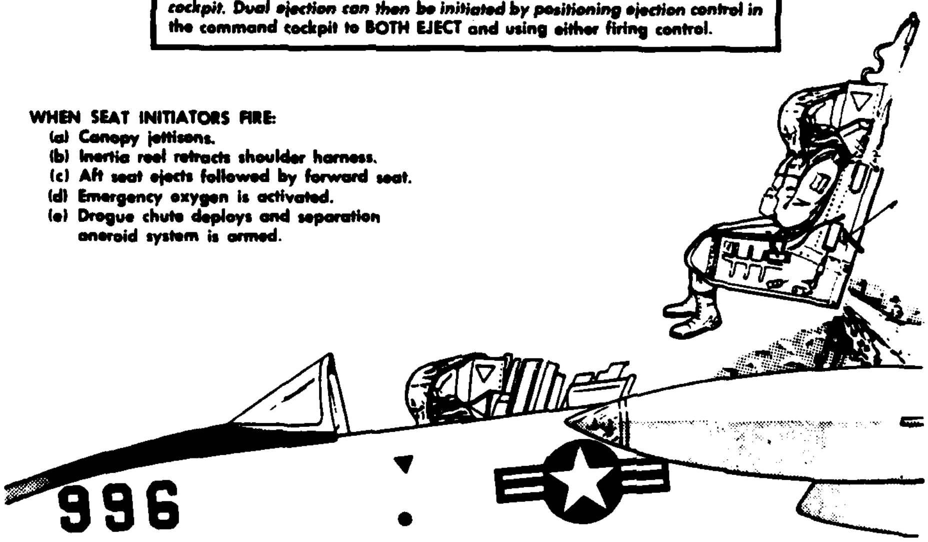
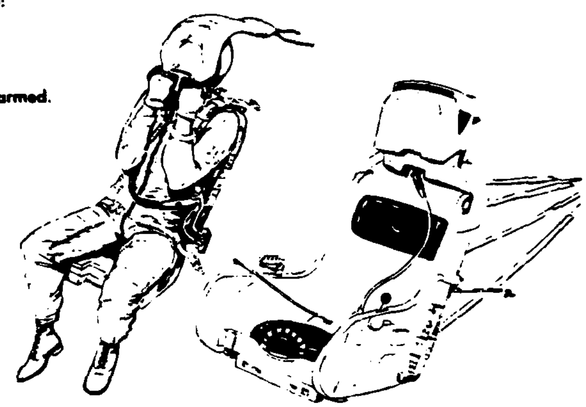


Figure 5

WHEN AUTOMATIC SEAT/MAN SEPARATION OCCURS (DELAYED UNTIL BELOW 13,000 FEET):

(a) Integrated harness is released.
(b) Face curtain cables are cut.
(c) Separation bladders inflate, forcing man from seat.
(d) Barometric parachute opener is armed.



IF AUTOMATIC SEAT/MAN SEPARATION FAILS TO OCCUR:
(a) SQUEEZE AND PULL HARNESS RELEASE HANDLE, LOCATED ON RIGHT-HAND SIDE OF EJECTION SEAT.
(b) ROLL CLEAR OF SEAT.

BELOW 10,000 FEET PARACHUTE OPENER IS INITIATED
0.75 SECOND AFTER SEAT/MAN SEPARATION.

(0.4 SECOND ON AIRCRAFT HAVING AFC 172)

IF BAROMETRIC OPENER FAILS, PULL MANUAL "D" RING.

6. REMOVE OXYGEN MASK AND DISCONNECT HOSE AFTER PARACHUTE DEPLOYMENT.
7. IF OVER WATER, INFLATE LIFE PRESERVER, THEN PULL SURVIVAL KIT RELEASE HANDLE TO DEPLOY AND INFLATE LIFE RAFT.
8. UPON CONTACT, RELEASE SHOULDER-HARNESS FITTINGS TO SEPARATE FROM PARACHUTE.

Figure 6

APPENDIX D

EJECTION SECTION OF NATOPS MANUAL FOR T-2 AIRCRAFT

—REWRITTEN VERSION—

EJECTION

Ejecting from a disabled aircraft requires the performance of two distinctly dif'erent sets of procedures. The first set covers the judgments to be made in deciding when to eject. These judgments involve: (1) assessing the ejection "envelope" or the aircraft's relationship to the limits of the ejection system, and (2) estimating the extent to which the aircraft can be flown to maintain or improve the relationship to the envelope. Two independent approaches to envelope assessment are included in the procedure: one relies on conservative altitude and airspeed *standards* while the other involves a more precise but also more complicated set of *approximation rules*.

The second set of procedures concerns the operation of the ejection hardware. The relatively few decisions in the operating procedures are quite simple, lending themselves to "cookbook" description, e.g., "if this, do that." Nevertheless, these procedures are critical, requiring rapid and accurate performance.

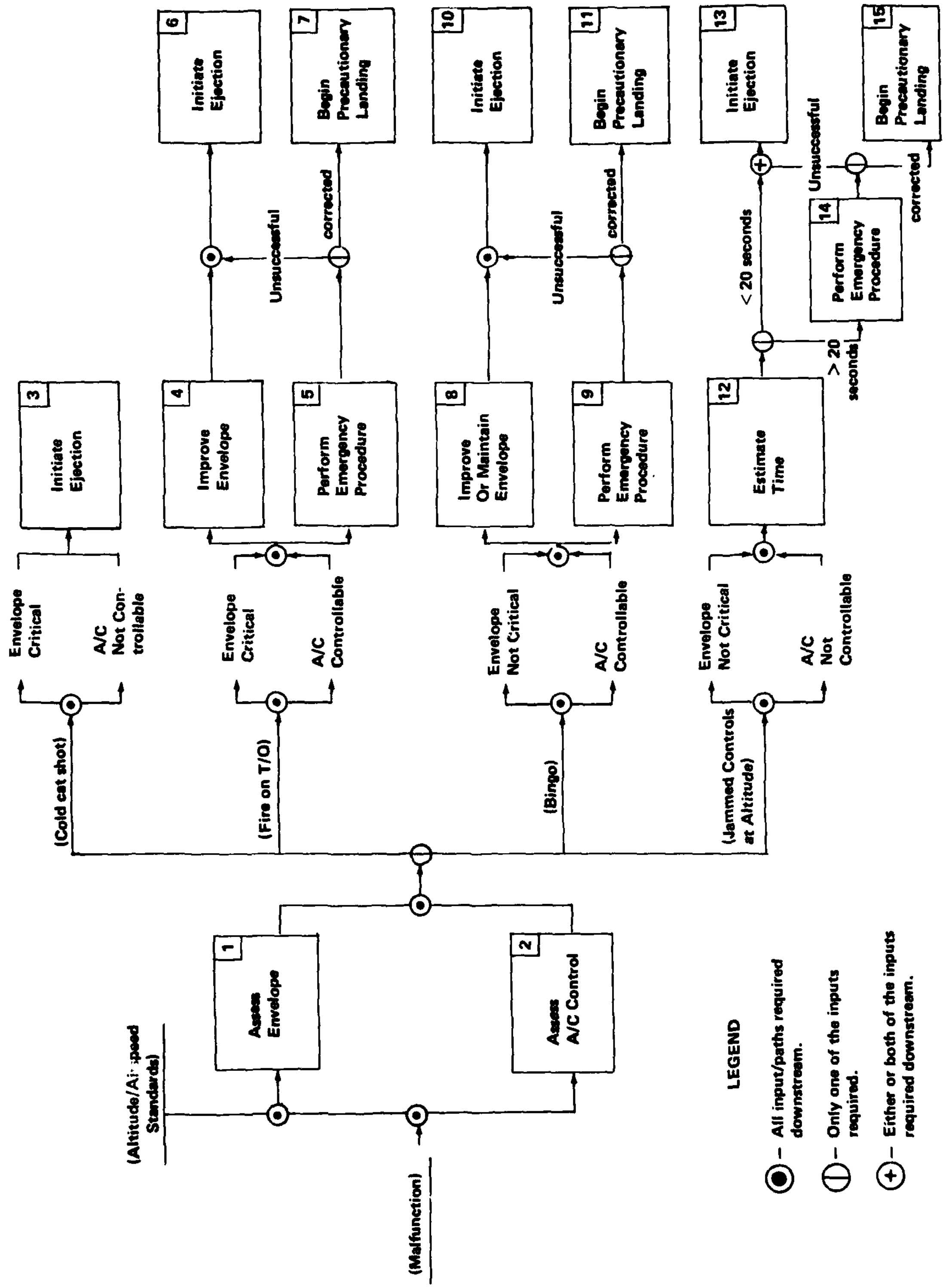
The information below discusses the procedures for both the timing decision and the equipment operation. The discussions are presented in the following order.

Ejection Timing Decision

Procedures

Figure 1 presents the ejection timing decision in diagrammatic form. As shown in blocks 1 and 2, the decision is made on the basis of: (1) envelope assessment and (2) aircraft controllability. Envelope assessment is defined as a judgment on how close the aircraft is to the operating limits of the ejection system. The outcome of this assessment can be either *critical* (near or beyond the limit) or *not critical*. Simultaneously, block 2 of the diagram calls for considering aircraft controllability to determine whether it is possible to maintain a good envelope or to improve a critical envelope. The outcome possibilities of this judgment are either: *controllable* or *not controllable*. The results of both judgments are combined, giving the four possibilities shown immediately after blocks 1 and 2.

The objective in applying this part of the ejection timing procedure is to characterize the aircraft situation as one of these four conditions. The emergency noted atop each condition is meant to typify that condition possibility. For example, "cold cat shot" is characterized as critical envelope, not controllable.


(Altitude/Ai- speed Standards)
(Malfunction)
1 Assess Envelope
2 Assess A/C Control
(Cold cat shot)
(Fire on T/O)
(Bingo)
(Jammed Controls at Altitude)
Envelope Critical
A/C Not Controllable
Envelope Critical
A/C Controllable
Envelope Not Critical
A/C Controllable
Envelope Not Critical
A/C Not Controllable
3 Initiate Ejection
4 Improve Envelope
5 Perform Emergency Procedure
8 Improve Or Maintain Envelope
9 Perform Emergency Procedure
12 Estimate Time
Unsuccessful
corrected
Unsuccessful
corrected
< 20 seconds
> 20 seconds
14 Perform Emergency Procedure
Unsuccessful
corrected
6 Initiate Ejection
7 Begin Precautionary Landing
10 Initiate Ejection
11 Begin Precautionary Landing
13 Initiate Ejection
15 Begin Precautionary Landing
LEGEND
– All input/paths required downstream.
– Only one of the inputs required.
– Either or both of the inputs required downstream.

The blocks following each condition possibility indicate the procedures appropriate for that condition. These procedures vary from "INITIATE EJECTION" to "BEGIN PRECAUTIONARY LANDING"; envelope improvement and emergency procedures are included as possible intermediate actions.

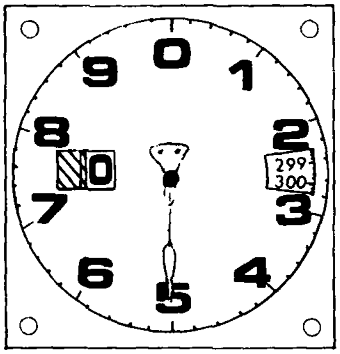
Required Inputs

Envelope assessment is the key to performing the ejection timing procedure. Two concepts are available to help perform this assessment. These concepts are referred to as "altitude and airspeed standards" and as "approximation rules".

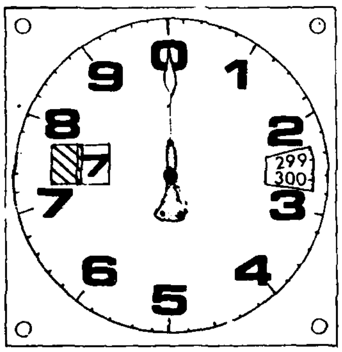
Altitude and Airspeed Standards. Ideal ejection conditions are defined in terms of airspeeds and altitudes. In the case of airspeed, the standards are based primarily on minimizing injury. In the case of altitude, the standards are based on specific malfunctions and their effect on the aircraft. These airspeed and altitude standards are relatively easy to use in assessing envelope criticality, but they are quite conservative in that they include large margins of safety.

Three types of altitude standards are relevant to the ejection timing decision. Two standards are keyed to specific emergency types (uncontrolled flight and power loss). The third is a minimum which applies in all cases regardless of the emergency which brought about the need for ejecting. The altitude and airspeed standards are summarized on the following pages in graphic form.

Altitude Standards

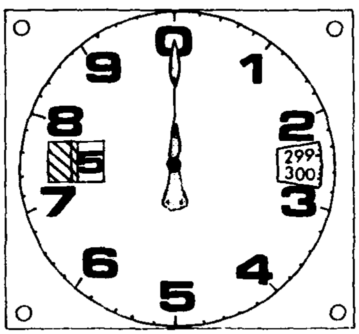


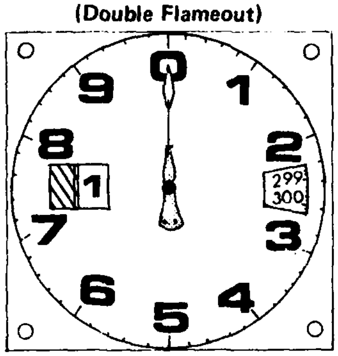
- For *All* Situations – Regardless of the emergency initiate ejection by at least *500 feet AGL*.

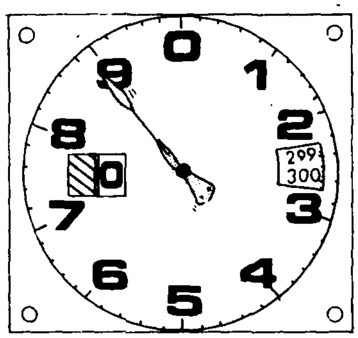


- For *Uncontrolled Flight* – Initiate ejection before reaching *7000 feet AGL*; or, if the aircraft goes out of control below 7000 feet, initiate ejection immediately

Power Loss on Both Engines (Double Flameout)

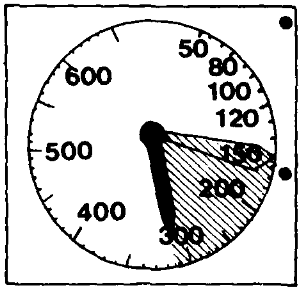






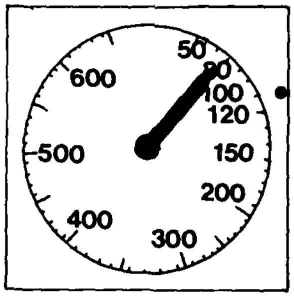
- If power loss occurs at altitude, try as many restarts as possible, but initiate ejection before *5000 feet AGL*.
- If power loss occurs below 5000 feet AGL, try one restart but initiate ejection before *1000 feet AGL*.
- If power loss occurs below *1000 feet AGL*, initiate ejection immediately, or if airspeed permits, convert and initiate ejection (viz., zoom-boom)

Airspeed Standard

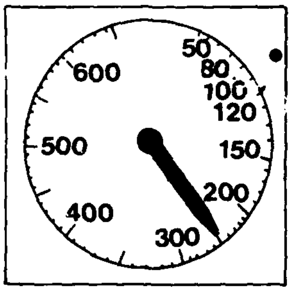


An upper airspeed limit of *320 kias* is established to minimize risk of injury from flailing and windblast.

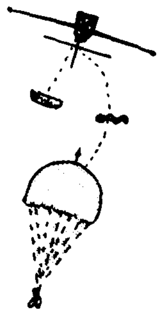
A lower airspeed limit of *150 kias* is established to minimize aircraft descent, which, if present, adds to altitude required for chute opening.



If ejection is necessary below 150 kias a second lower limit of *75 kias* is recommended to minimize risk of collision with jettisoned canopy.



If bailout is considered, a maximum airspeed of *250 kias* is recommended to ensure clearance of the tail section.



WARNING. Bailout should be considered only after all primary and alternate means of ejection have failed. Even then ditching may be preferred to bailout.

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AN EVALUATION OF A NEW FORMAT FOR PRESENTING EJECTION INFORMATI--ETC(U)
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Altitude and airspeed standards should be the first basis considered for assessing ejection envelope. Referring to Figure 1, this means that altitude and airspeed standards should be inputs to block # 1. Under special circumstances discussed below, it may be appropriate to abandon the standards, with their large margins of safety, in favor of the more precise approximation rules.

Approximation Rules. The ejection system imparts a fixed amount of thrust to the seat occupant, propelling him away from the aircraft. Assuming that the aircraft is stationary on the ground, the amount and direction of this thrust (a vector) are such that the seat occupant travels in a trajectory which gives enough time for the chute to open just prior to impact. However, when the aircraft is airborne, *rate of descent*, *dive angle*, *angle of bank* and *airspeed* set up vectors which oppose the ejection vector. Unless the aircraft is flown to arrest these opposing vectors, or unless sufficient altitude is available to compensate for their detrimental effect, the system may not have enough time to open the chute before ground impact.

Computations and test data have defined the altitudes required to compensate for various levels of descent, dive angle and angle of bank as a function of airspeed. These relationships can replace airspeed and altitude standards as the basis for assessing ejection envelope *if it is appropriate to sacrifice some of the safety margin of the standard approach in favor of more time to save the aircraft.* However, the risk of injury increases as the aircraft goes beyond the standards, reaching a maximum at the compensating altitudes defined here. The result is that extra time can be obtained but the cost is increased risk.

These altitudes are defined by complex charts which do not lend themselves to memorization. Accordingly, simpler rules are presented to help approximate the actual altitude values. These approximation rules are presented along with the charts which define the actual relationships on the following pages. The top of each figure presents the approximation rule and examples of its use. The lower portion of each figure presents the graphic definition of the pertinent relationship.

Since the rules are only approximations, it is appropriate to practice their use on a range of ejection conditions in order to learn: (1) how to use them and (2) where the rules provide too much or too little altitude.

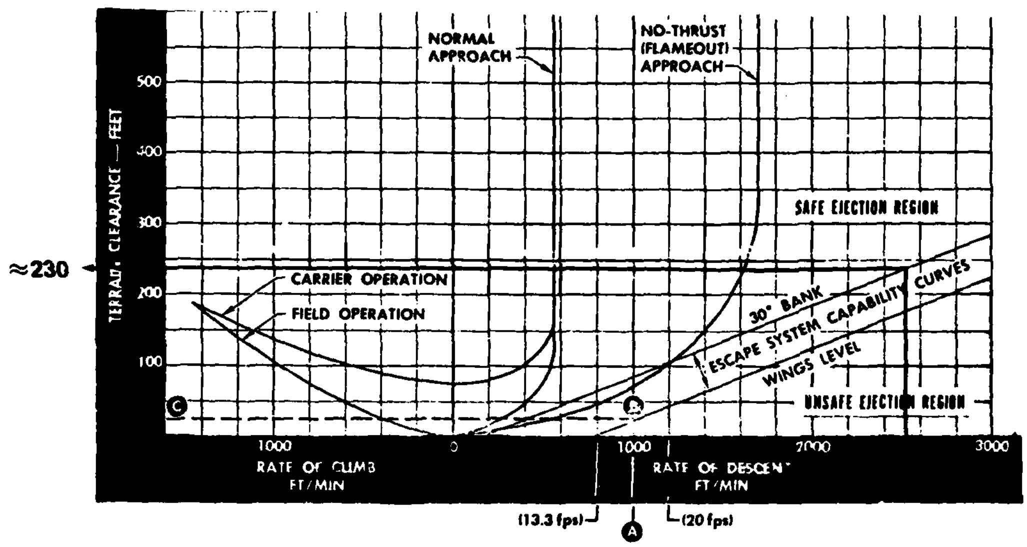
MINIMUM SAFE EJECTION ALTITUDES

RATE OF DESCENT

RULE: Altitude = Rate of Descent X 10%

Example: 2500 fpm rate of descent, 30° bank

- **2500 x 10% = 250 feet vs. chart reading of 230 feet.**



Notes:

1. Information presented assumes that the aircraft is under control until seats leave the airplane.
2. For 90° bank add 250 feet to terrain clearance required for wings level.
3. For inverted flight, add 500 feet to terrain clearance required for wings level.
4. Escape system capability curves include:
   a. The data for the curves plotted are based on a 95 percentile man ejecting from the front cockpit and includes a two second reaction time by the crewman. The two second reaction time allowance means that sufficient altitude and time has been incorporated into the curves to provide for parachute deployment. Therefore, for a given point on the minimum safe ejection curve, if the crewman initiates the seat system within two seconds, he will be recovered.
   b. Minimum safe ejection altitude for the escape system capability curves is defined as complete parachute inflation just prior to ground contact for the 95 percentile pilot ejecting from the front cockpit.
   c. Normal aircraft pitch for conditions shown is +15°.
5. Curves labeled "Normal Approach", "No Thrust (Flameout) Approach", "Field Operation" and "Carrier Operation", are typical curves shown for reference only. Do not use them to read height for safe ejection. The approach and climb curves relate to the aircraft characteristics and indicate that the flight paths are in the safe ejection region of escape system capability curves for wings level and for much of the flight path at 30° bank.

Example:

To determine minimum safe ejection altitude for conditions of 1000 fpm (16.7 fps) rate of descent, aircraft wings level, nose attitude +15° first enter the chart at Point A. Point A intersects the wings level curve at Point B, which defines the altitude at Point C, approximately 25 feet. A 95 percentile pilot in the front cockpit initiating his seat system within two seconds under the described conditions would be recovered (assuming surface contact in landing configuration with 75 knots airspeed.)

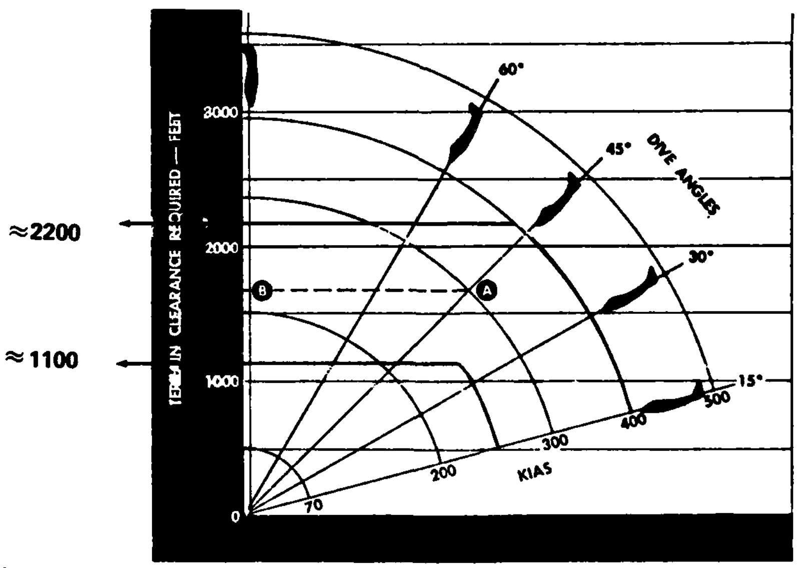
MINIMUM SAFE EJECTION ALTITUDES

DIVE ANGLE

RULES:	**15° = Altitude ≈ Airspeed X 2**
	30° = Altitude ≈ Airspeed X 4
	45° = Altitude ≈ Airspeed X 6
	60° = Altitude ≈ Airspeed X 8

Example: For 250 KIAS and 35° Dive Angle
- **(35° is closest to 30°)**
- **Altitude = 250 X 4 = 1000**
  (Versus 1100 from Chart)

Example: For 400 KIAS and 48° Dive Angle
- **(48° is closest to 45°)**
- **Altitude = 400 X 6 = 2400 feet**
  (Versus 2200 from Chart)



Notes:

1. Curves are based on a 95 percentile man ejecting from the front cockpit and includes a two second reaction time to initiate seat system.
2. Curves are based on wings level dive attitude and appropriate angle of attack.
3. Minimum safe ejection altitudes for the curves depicted are defined as full inflation of the parachute obtained prior to ground contact for a 95 percentile crewman ejecting from the front cockpit of the airplane.

Example:

The aircraft is at a 45 degree dive angle, wings level at an airspeed of 300 KIAS (point A), point B indicates an altitude of approximately 1700 feet. Providing the 95 percentile man in the front cockpit initiates the seat system within two seconds after reaching this point, his parachute will be inflated just prior to ground contact.

LS1-A SEAT

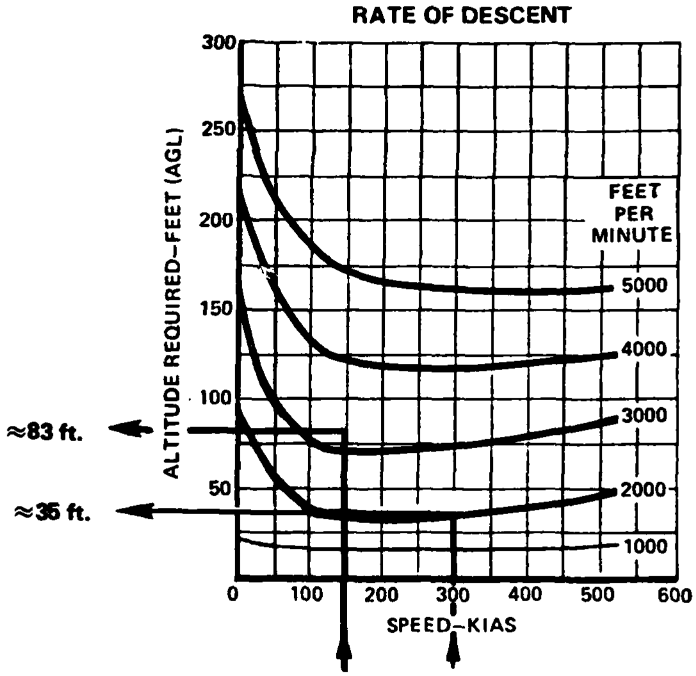
MINIMUM SAFE EJECTION ALTITUDES
RATE OF DESCENT

RULE: Required Altitude = 3% X Rate of Descent

Example: For a 2000 fpm Rate of Descent at 300 KIAS
- Altitude = 3% X 2000 = 60 feet (vs. 35 from the Chart)

Example: For a 3200 fpm Rate of Descent at 150 KIAS
- Altitude = 3% x 3200 = 96 Feet (vs. 83 from the Chart)

CAUTION: When Airspeed is Below 100 KIAS, Double the Altitude Required



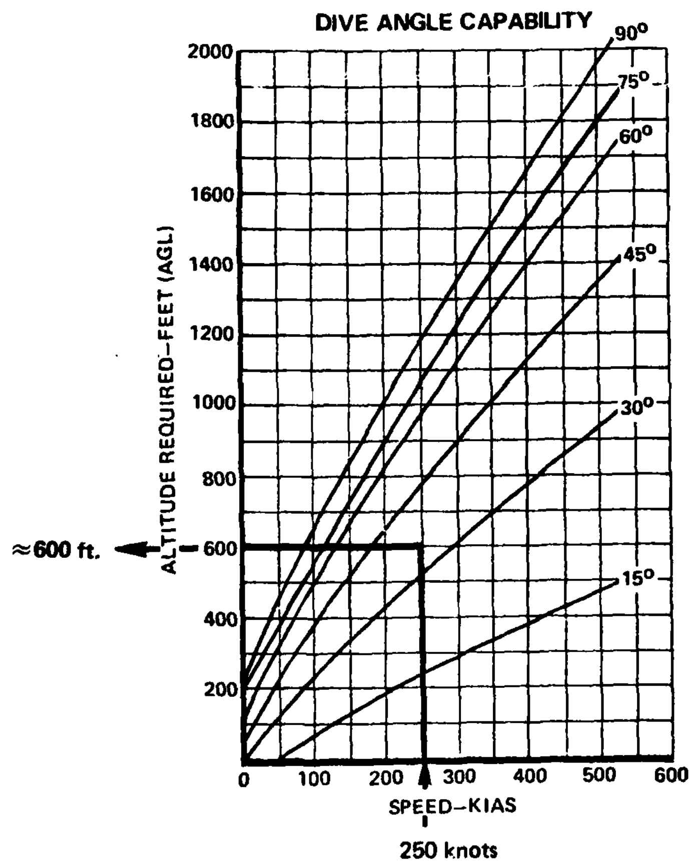
NOTE: Use Rate of Descent up to 6000 fpm (the Limit of the Instrument). Thereafter Use Dive Angle.

MINIMUM SAFE EJECTION ALTITUDES
DIVE ANGLE

RULE: Altitude = Airspeed X the Number of Dive Angle Lines (The Approximation Rule is Based on the Graph's Six Dive Angle Lines Proceeding from 15° to 90° in 15° Increments).

Example: For 250 KIAS and 35° Dive Angle
- **(35° is Closest to 30° or the Second Dive Angle Line)**
- **Altitude = 250 x 2 = 500 Feet (Versus 600 from Chart)**

CAUTION: For High Dive Angle the Approximation Rule Tends to give too much Altitude for High Speed and too Little for Low Speeds.



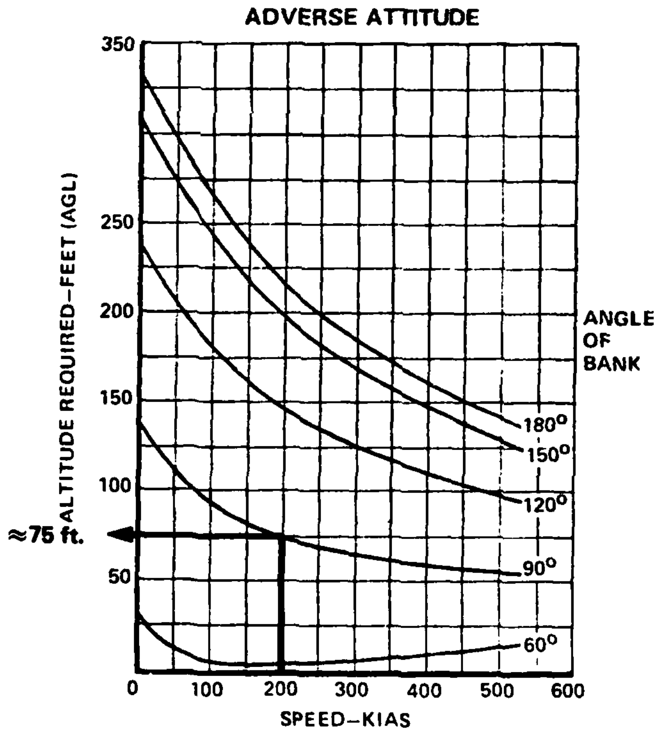
NOTE: Use Dive Angle When Rate of Descent Exceeds the Aircraft's Instrument Capability of 6000 fpm.

MINIMUM SAFE EJECTION ALTITUDES
ADVERSE ATTITUDE (ANGLE OF BANK)

RULE: Altitude to Compensate for Angle of Bank
- **1 Foot for Each 1° – for Speeds Over 300 kias**
- **1½ Feet for Each 1° – for Speeds Under 300 kias**

Example: The Altitude Required for Rate of Descent is 400 feet; the Angle of Bank is 90°; and the Airspeed is 200 kias.

Altitude to Compensate for Angle of Bank =
- 90° x 1½ = 135 feet (vs. 75 feet from chart)
- 400 Feet + 135 Feet = 535 Feet (vs. 475 feet from chart)



NOTE: Altitude Required by Angle of Bank must be Added to Altitude Required by Dive Angle or Rate of Descent.

Operating Procedures

Having decided to eject, and having done everything reasonable to ensure that the abandoned aircraft will inflict the least damage on impact, the pilot can perform the ejection procedures. These procedures are organized into three phases and eleven segments. The steps necessary to perform each segment are presented on the following pages.

I. PREPARATORY
   - A. Communicate
   - B. Adjust Equipment
   - C. Position Body for Ejection

II. EJECTION
   - A. Initiate Ejection
   - B. Note Automatic Ejection Events
   - C. Initiate Alternate Ejection Sequence
   - D. Initiate Bail-out Sequence
   - E. Seat/Man Separation

III. DESCENT
   - A. Parachute Opening
   - B. Prepare for Landing
   - C. Landing

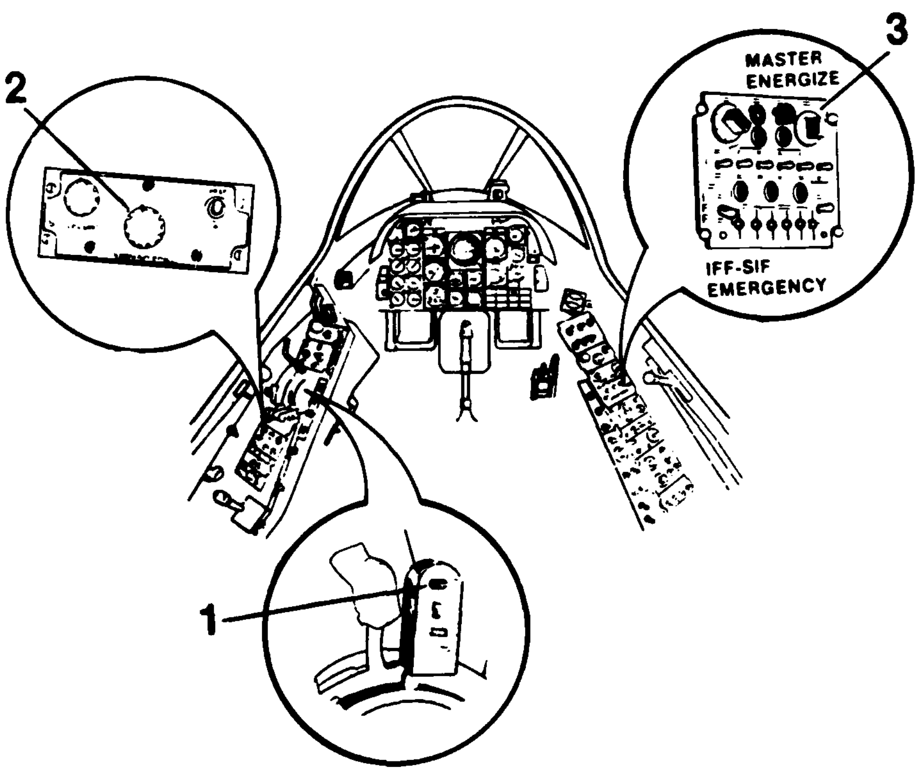
I. PREPARATORY

A. Communicate

1. Warn crewman on intercom (1)

NOTE: Do the following only if time permits

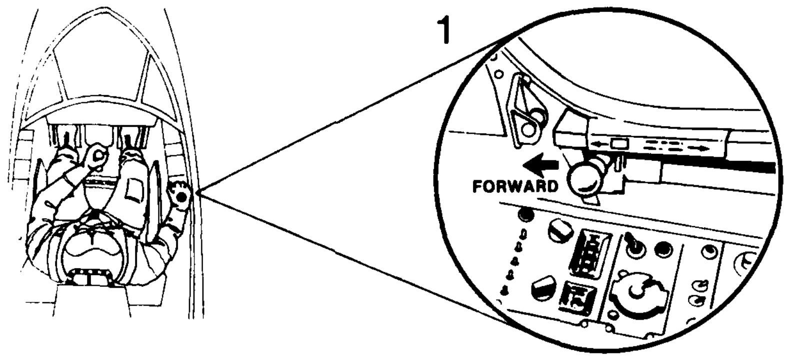
2. Switch to guard channel (2)
3. Switch IFF-SIF to emergency (3)
4. Transmit your identification followed by three "Maydays."
5. Transmit: – Position
   – Altitude
   – Nature of emergency
   – Intended actions
6. Monitor guard channel



I. PREPARATORY

B. Adjust Equipment

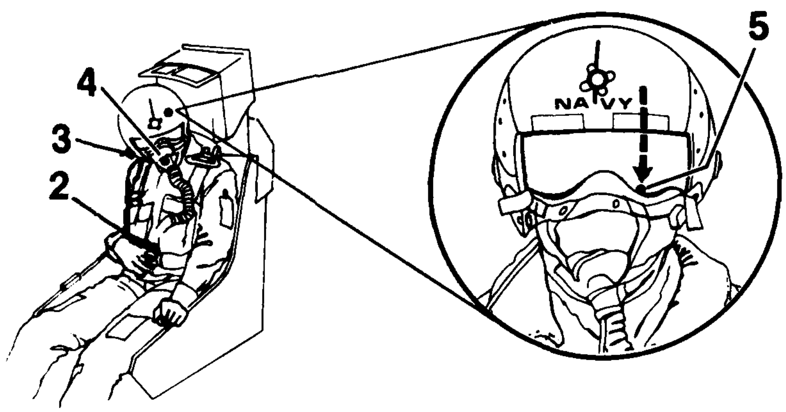
1. Set selector handle in command cockpit to "Both Eject." If command cockpit is front cockpit, set selector *forward* to "Both Eject." (1)



Front Cockpit

If command cockpit is rear cockpit, set selector *aft* to "Both Eject."

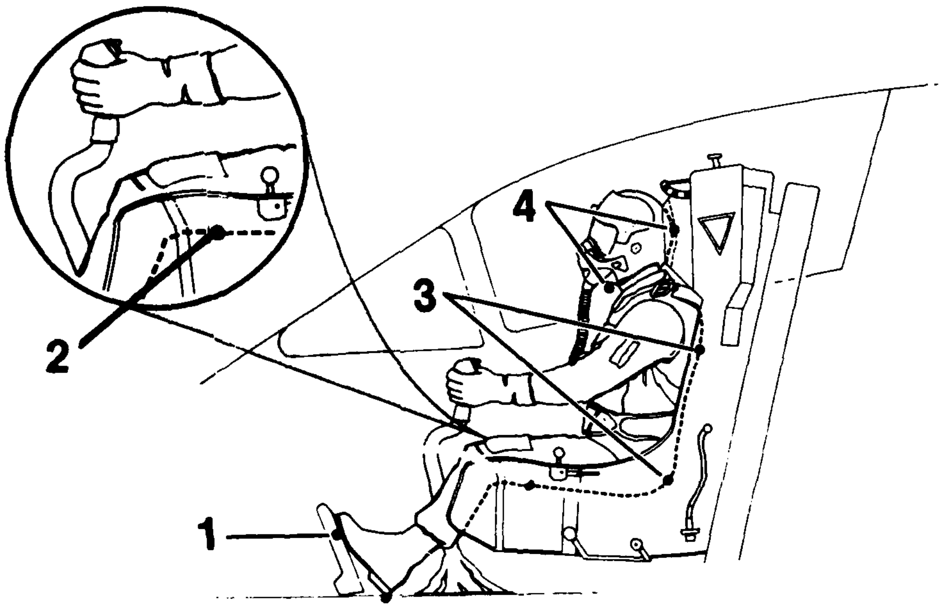
2. Tighten lap belts (2), helmet strap (3), and oxygen mask (4)
3. Check helmet visor down and locked (5)
4. Remove kneeboard



C. Position Body for Ejection

1. Place heels on deck and balls of feet on rudder pedals (1)
2. Move knees outboard with thighs as flat as possible on seat cushion (2)
3. Push buttocks back, sit erect (3)
4. Move head back against headrest and hold chin up (4)

WARNING: Incorrect posture increases your chances of injury during ejection



II. EJECTION

A. Initiate Ejection

FACE CURTAIN

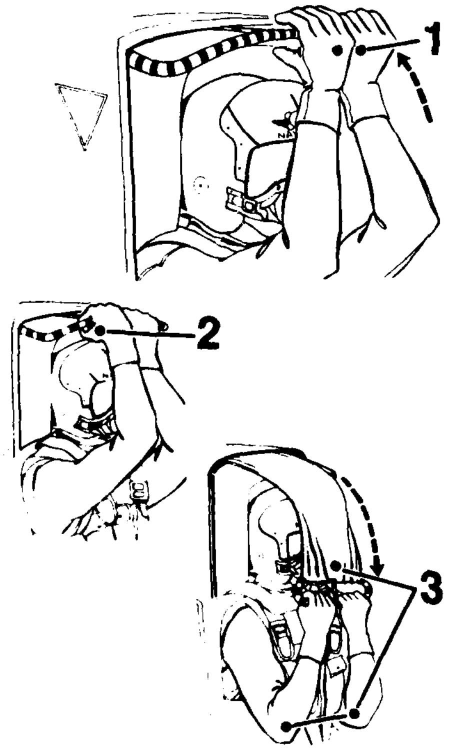
1. Reach overhead with palms aft and heels of hands together. (1)
2. Grasp face curtain handle, closing thumbs around fingers. (2)
3. Slam face curtain handle down in one continuous movement and keep elbows close to body.

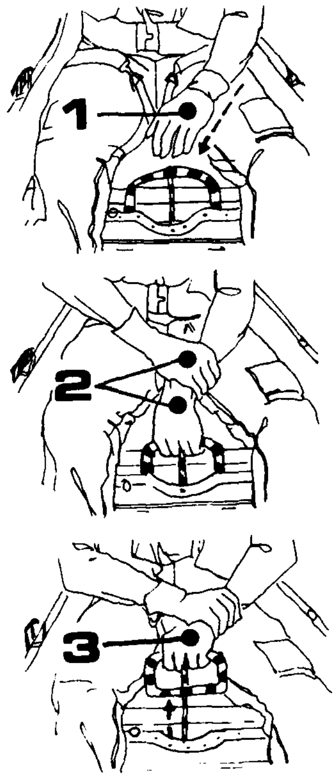
LOWER EJECTION HANDLE (LEH)

> **NOTE:** Fly with the right hand, reach with the left.

1. Reach toward LEH with other hand, palm facing aft. (1)
2. Grasp lower ejection handle (LEH) holding wrist with opposite hand. (2)
3. Pull LEH upward (2) (not aft) through about 3 inches of travel. Approximately 75 lbs. of force required.

> **NOTE:** Ejection sequence is the same regardless of control used. Use either Face-Curtain or Lower Ejection Handle (LEH) to initiate ejection. The LEH is preferred for low altitude or low airspeed situations where fast ejection is important.



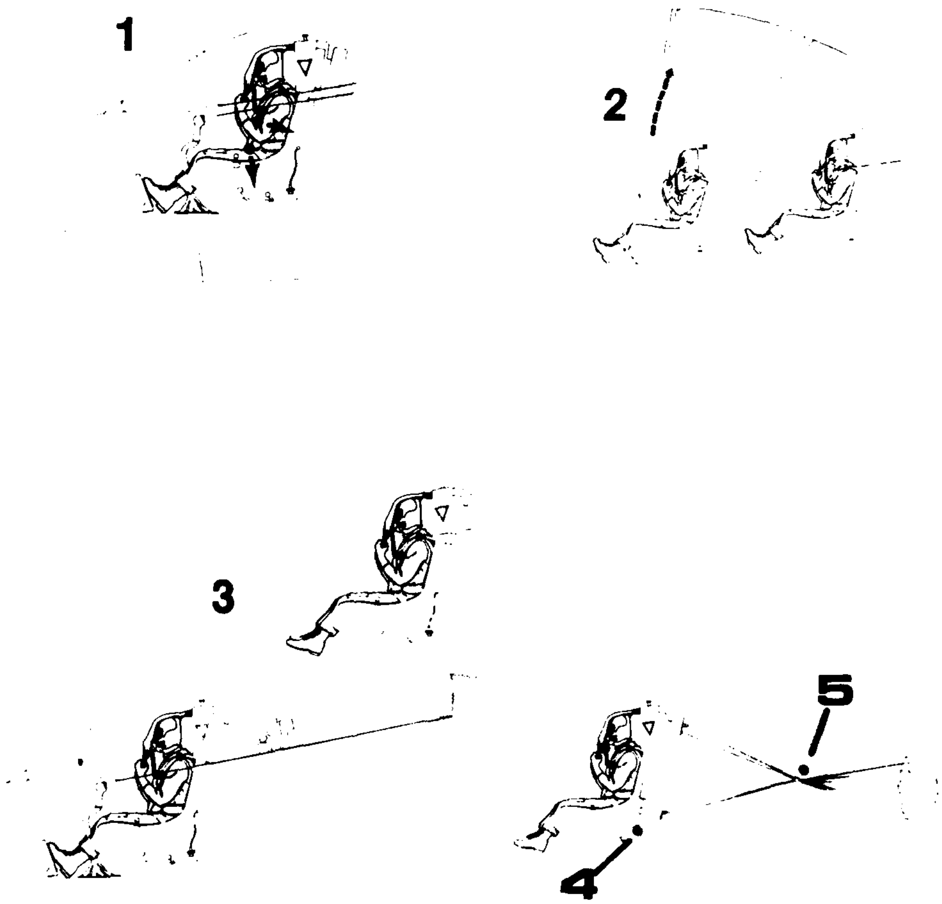


II. EJECTION

B. Note Automatic Events

1. Inertia reel retracts shoulder harness (1)
2. Canopy jettisons (2)
3. Aft seat ejects followed by forward seat (3)
4. Emergency oxygen is activated (4)
5. Drogue chute deploys (5) and separation aneroid system is armed

NOTE: The events above occur automatically with the firing of the seat initiators

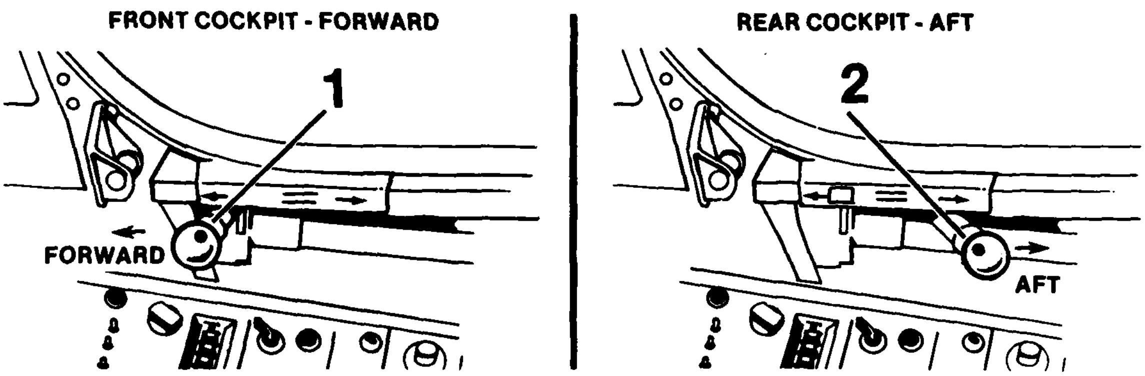


II. EJECTION

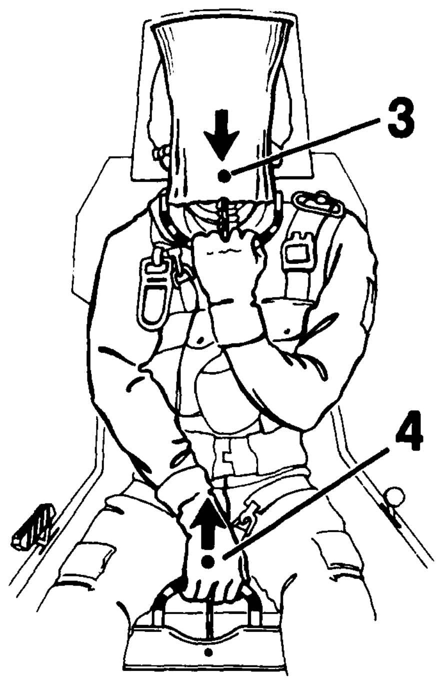
C. Initiate Alternate Ejection Sequence

If ejection fails using one firing handle:

1. Check that command selector handle is correctly positioned to "Both Eject" (1)



2. Initiate ejection using other firing handle



> CAUTION: If the failed attempt was with the face curtain, hold on to face curtain with one hand while lifting LEH with the other to prevent flailing of curtain handle.

> CAUTION: If both controls fail with one cockpit as command, switch command to other cockpit and try again.

D. Initiate Bail-Out Sequence

> NOTE: If all tries to eject fail, consider ditching or bail-out. Bail-out procedures follow.

1. Inform crewmen of bail-out intention (1)
2. Check that canopy is locked (2)

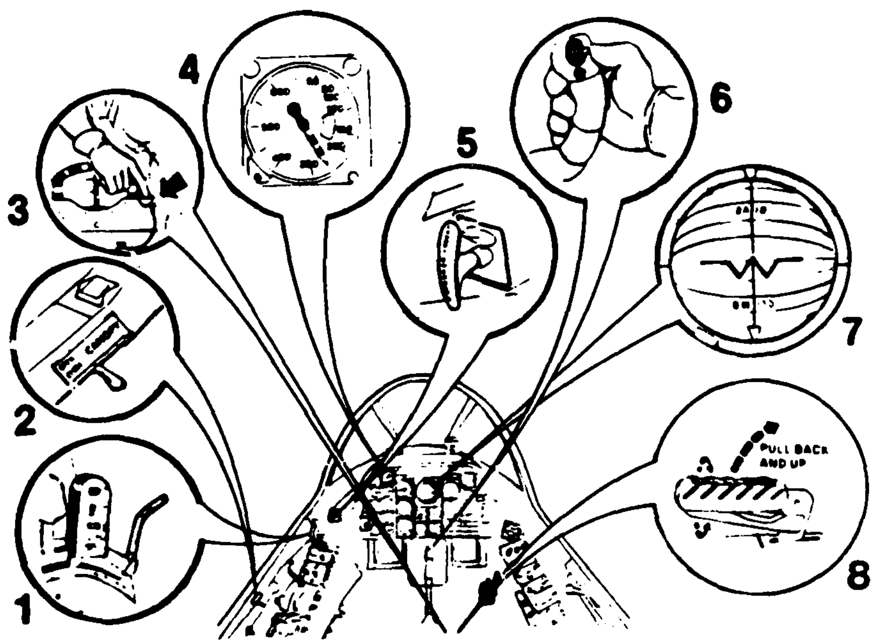
> WARNING: The canopy may not jettison if it is not fully closed.

3. Pull emergency oxygen actuator (3)
4. Establish airspeed at about 250 KIAS (4)
5. Jettison canopy by pulling emergency canopy release handle (5)

> NOTE: 250 KIAS is needed to clear tail section

6. Trim for full nose down (6)
7. Roll aircraft to inverted position (7)
8. Squeeze and pull emergency restraint release (8)

> CAUTION: For bail-out parachute must be opened manually.



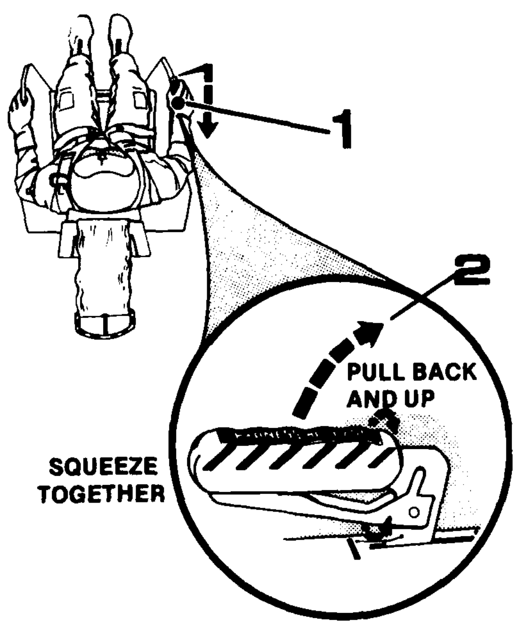
II. EJECTION

E. Seat/Man Separation

Manual Separation

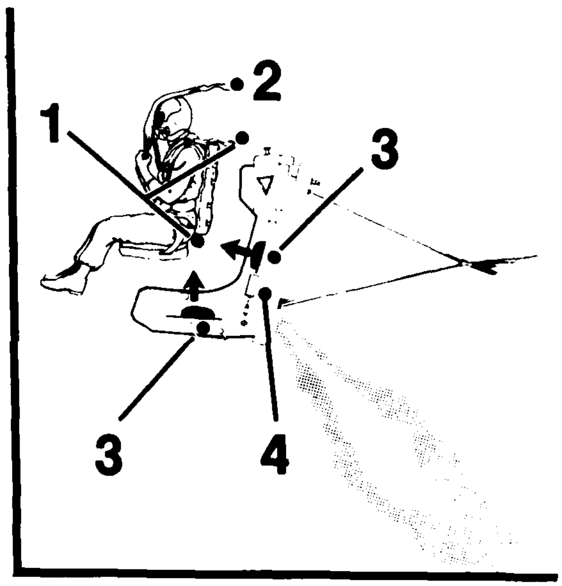
> **NOTE:** If ejecting below 13,000 feet or if automatic seat/man separation fails, initiate manual release.

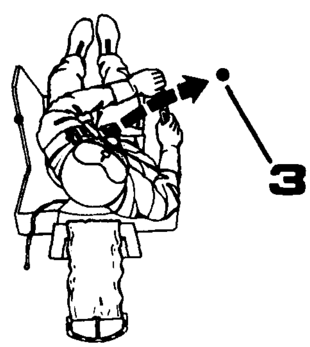
1. Squeeze emergency restraint release (1)
2. Pull back and up (2)
3. Roll clear of seat (3)



Automatic Separation

1. Torso harness is released (1)
2. Face curtain cables are cut (2)
3. Separation bladders inflate, forcing you from seat (3)
4. Barometric opener is armed (4)



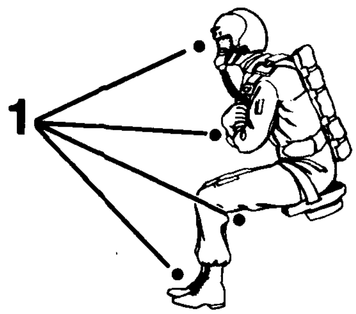


III. DESCENT

A. Parachute Opening

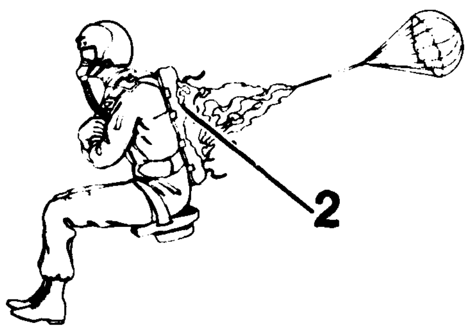
> **NOTE: If ejecting below 10,000 feet, parachute opener is initiated .75 seconds after seat/man separation. Otherwise, barometric opener is set to operate at 10,000 feet.**

1. Before chute opens:
   - Assume a tucked position
   - Cross arms
   - Keep legs together
   - Keep head up



Automatic

2. Wait for parachute opener to release chute



Manual

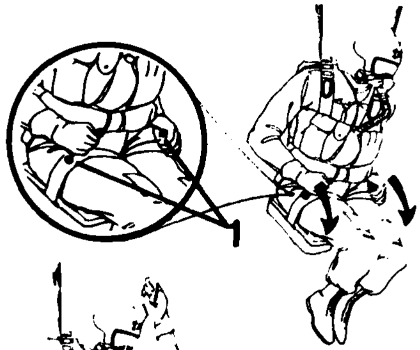
3. Reach up and across with right hand and pull parachute ripcord

III. DESCENT

B. Prepare for Landing

If over water:

1. Inflate life preserver by pulling both inflation assembly lanyards (1) down and forward in one continuous motion.



2. Pull raft release (2) to deploy and inflate life raft.

3. Remove oxygen mask and pull away hose (3).

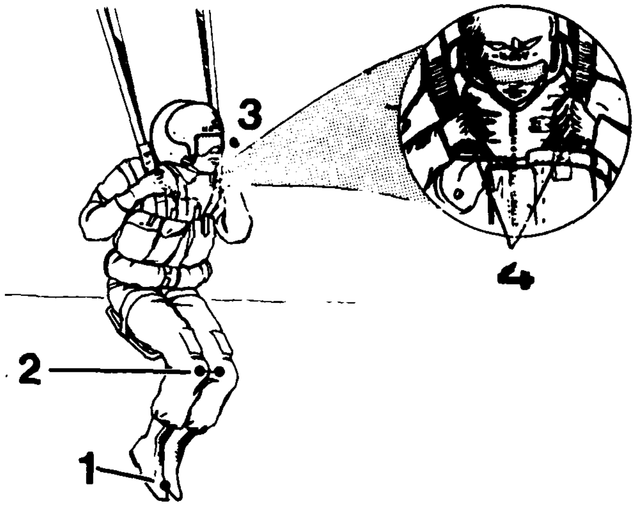
If over land:

1. Do not release survival kit. Keep survival kit intact as protection in case of tree landing.
2. Remove oxygen mask and pull away hose as in (3) above.

C. Landing

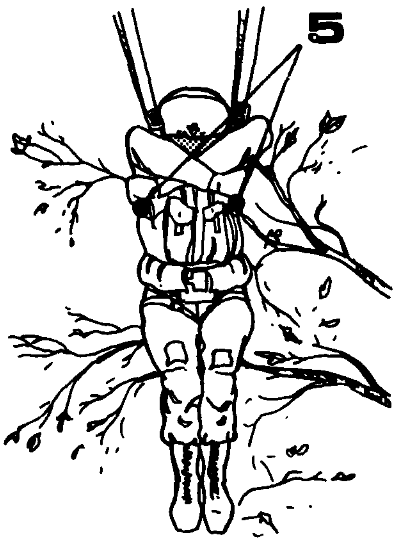
For both land and water landing:

1. Take posture for landing:
   - Feet together (1)
   - Knees slightly bent (2)
   - Look to horizon, not down (3)



2. Place hands on koch fittings (4)

3. Release koch fittings only after contact with surface.



4. For tree landing or for night landing, keep feet together and cross arms to protect main artery located in underarm region.

> **WARNING:** When above water, do not anticipate landing by releasing harness early. Wait until feet are wet.

APPENDIX E

OPINIONS OF SUBJECTS REGARDING NATOPS EJECTION PRESENTATIONS

User Acceptance Survey

Introduction

An effective Technical Information system must have good user acceptance, in addition to being easily understood and/or learned. A particular TI system may have good readability and produce good learning and performance, but still fail to be effective because the intended audience does not accept and use it.

The user acceptance of the Ejection Technical Information was explored via a 14-item questionnaire (see Exhibit E-1). The questionnaire was administered to all subjects (experimental and control, SNAs and SNFOs) following the completion of their retention test. Thirteen items of the questionnaire asked subjects to use a four or five point scale to indicate their feelings about an identified feature of the NATOPS presentation they studied. A fourteenth item asked subjects to rate ten selected features of the NATOPS presentations, using a five-point rating scale.

Results

Following the questionnaire are two sections presenting bar-graph summaries of the SNA and SNFO responses to the TI acceptance questions (1-13). The right sides of the graphs show the experimental subjects' responses; those on the left are the control subjects' responses. A tabular format is used to summarize the responses to the fourteenth questionnaire item.

Observations about the user acceptance results are as follows:

- The rewritten (experimental) presentation was consistently favored over the NATOPS presentation appearing in manuals (control).
- The SNFOs, who, at the time of the experiment, had not been exposed to any T-2 training, favored the experimental writeup more strongly than did their SNA counterparts, who had completed all or major parts of the T-2 curriculum.
- Noteworthy SNA responses are identified below, along with the number of the question to which they apply:
  - Superior organization of the experimental presentation (#6).
  - Superior clarity of the experimental ejection standards (#10).
- Noteworthy SNFO responses are identified below (question number in parenthesis).
  - Superiority of the experimental presentation's coverage of the safe envelope (#2).
  - Superiority of the ejection standards of the experimental writeups (#10).
  - Inferiority of the control presentation's ability to help locate equipment (#13).
  - In item #14, clearly favorable responses were obtained for the experimental presentation in general.

Exhibit E-1
Questionnaire

(1) ***Were the illustrations helpful in recalling the ejection operating procedures?***

(a) definitely yes
(b) in most cases
(c) usually
(d) in some cases
(e) seldom
(f) other ____

(2) ***Did the supplement help in the understanding of "safe" envelope assessment?***

(a) definitely yes
(b) in most cases
(c) usually
(d) in some cases
(e) seldom
(f) other ____

(3) ***Does the procedure section contain the information needed to initiate ejection properly and safely?***

(a) yes, under all conditions
(b) yes, under most conditions
(c) some information is missing, but supplement is still useful
(d) no, crucial information is missing
(e) other ____

(4) ***Do you feel you have the ejection procedures mastered?***

(a) entirely
(b) almost entirely
(c) mostly
(d) to some degree
(e) not at all
(f) other ____

Exhibit E-1 (Continued)

Questionnaire

(5) *Did you have any difficulty in understanding the procedures?*

(a) no difficulty at all
(b) very little difficulty
(c) occasionally
(d) almost always
(e) always
(f) other ______________________________

(6) *Are the materials in the supplement well-organized?*

(a) yes, always
(b) in most cases
(c) usually
(d) in some cases
(e) seldom
(f) other ______________________________

(7) *Do you feel the organizational plan of the materials in the supplement was*

(a) very helpful
(b) usually helpful
(c) fairly helpful
(d) not very helpful
(e) no help at all
(f) other ______________________________

(8) *The graphics were:*

(a) very helpful
(b) helpful
(c) fairly helpful
(d) helpful, but not necessary
(e) not needed at all
(f) other ______________________________

Exhibit E-1 (Continued)

Questionnaire

(9) *To what extent do you feel the procedure headings helped you to memorize the materials?*

(a) always
(b) frequently
(c) sometimes
(d) seldom
(e) never
(f) other ______________________________

(10) *Were the ejection standards for altitude and airspeed clearly defined?*

(a) yes, always
(b) in most cases
(c) usually
(d) in some cases
(e) seldom
(f) other ______________________________

(11) *Do you feel more confident about assessing the ejection envelope after reviewing the supplement?*

(a) most definitely
(b) yes, in most cases
(c) to some degree
(d) for some cases, but not many
(e) not at all
(f) other ______________________________

(12) *Do you feel more confident in your knowledge of the ejection operation procedures after reviewing the supplement?*

(a) most definitely
(b) yes, in most cases
(c) to some degree
(d) for some cases, but not many
(e) not at all
(f) other ______________________________

Exhibit E-1 (Continued)

Questionnaire

(13) *Do you feel more confident of your ability to locate ejection operation equipment as a result of using the supplement?*

(a) most definitely

(b) yes, in most cases

(c) to some degree

(d) in a few cases

(e) not at all

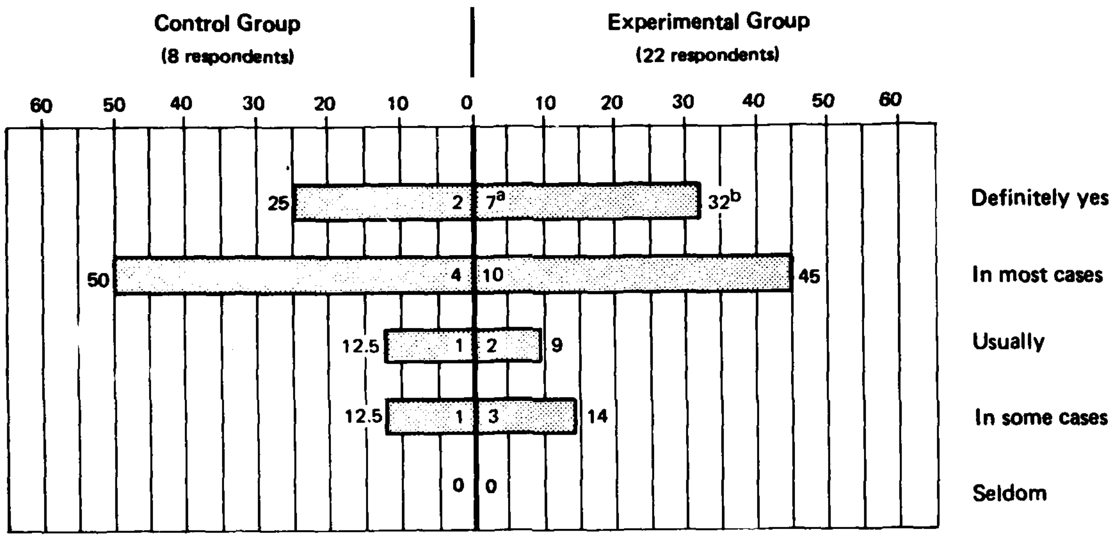
(f) other

(14) The following features are to be rated as to their *contribution* towards helping you understand and comprehend the materials.

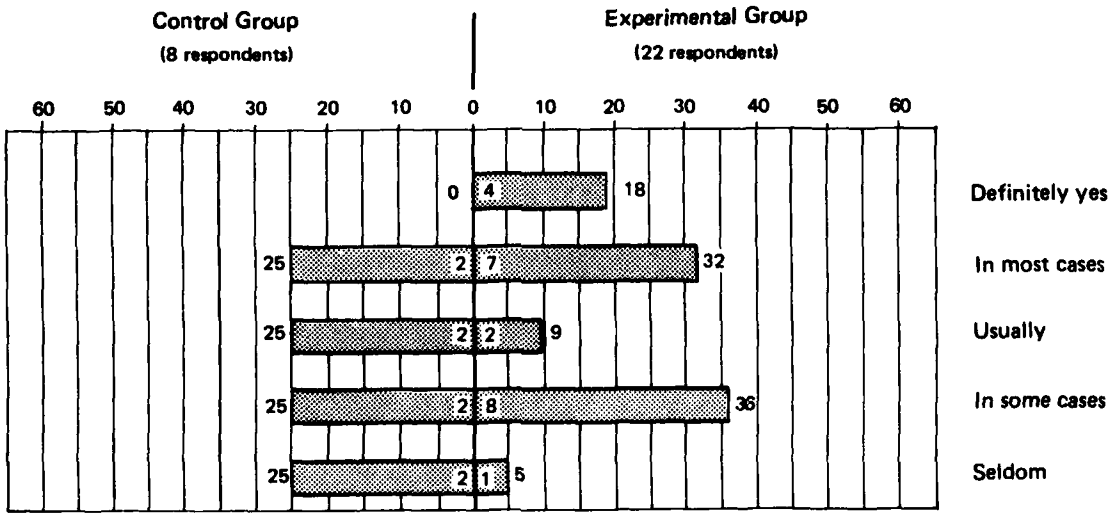
	Very Good	Good	Fair	Poor	Very Poor
1. Pictorial coverage of ejection equipment items.					
2. Number of illustrations depicting ejection operations.					
3. Pictorial coverage of envelope assessment equipment items.					
4. The location and identification of ejection operation equipment.					
5. The labeling of relevant ejection procedures.					
6. The organizational layout of the envelope assessment.					
7. The explicitness of ejection operation procedures.					
8. Placement of notes and warnings.					
9. Readability of the envelope assessment text.					
10. Overall appearance of the supplement.					

Student Naval Aviator (SNA) Responses to Questionnaire

1. ***Were the illustrations helpful in recalling the ejection operating procedures?***



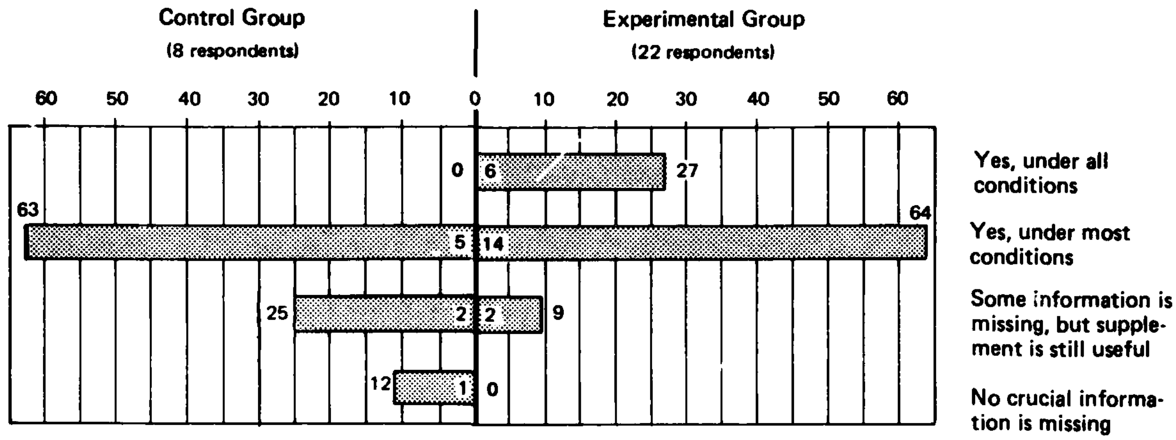
2. ***Did the supplement help in the understanding of "safe" envelope assessment?***



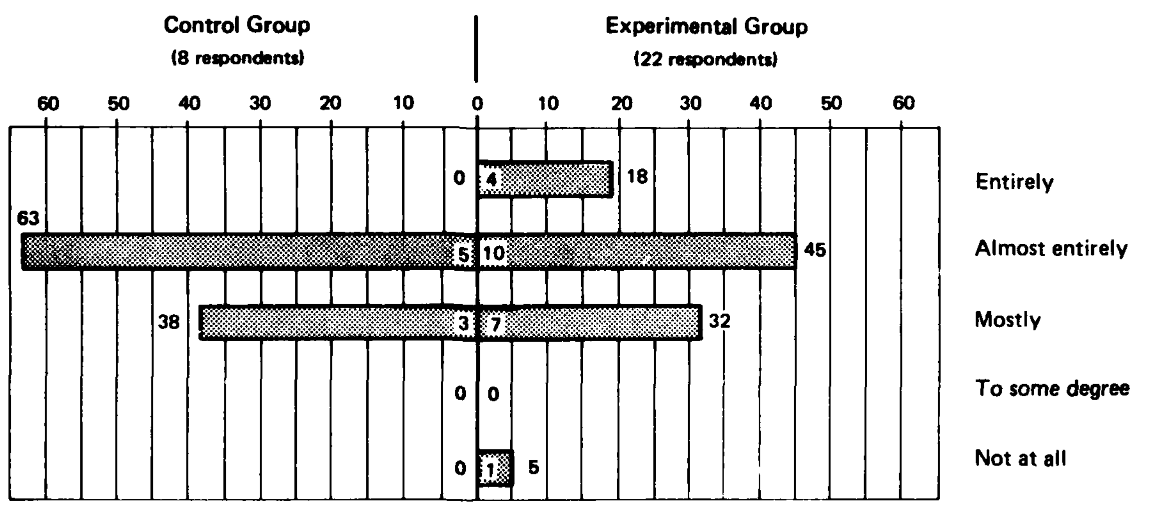
[a]Number at center is number of subjects that chose this response.

[b]Number outside bar (or at extreme tip) is percentage (approx.) of group represented by this number of respondents.

3. *Does the procedure section contain the information needed to initiate ejection properly and safely?*

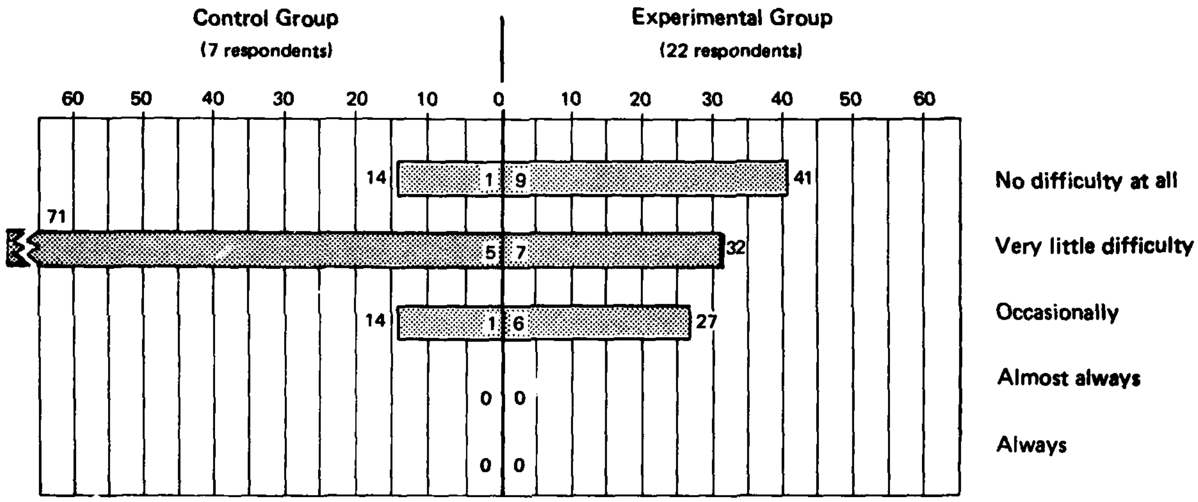


4. *Do you feel you have the ejection procedures mastered?*

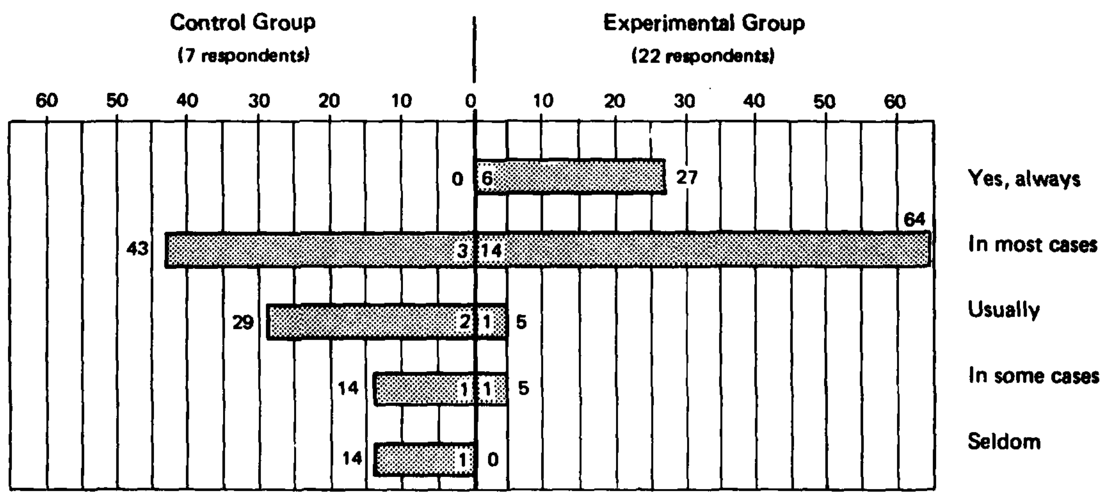


Student Naval Aviator (SNA) Responses to Questionnaire *(Continued)*

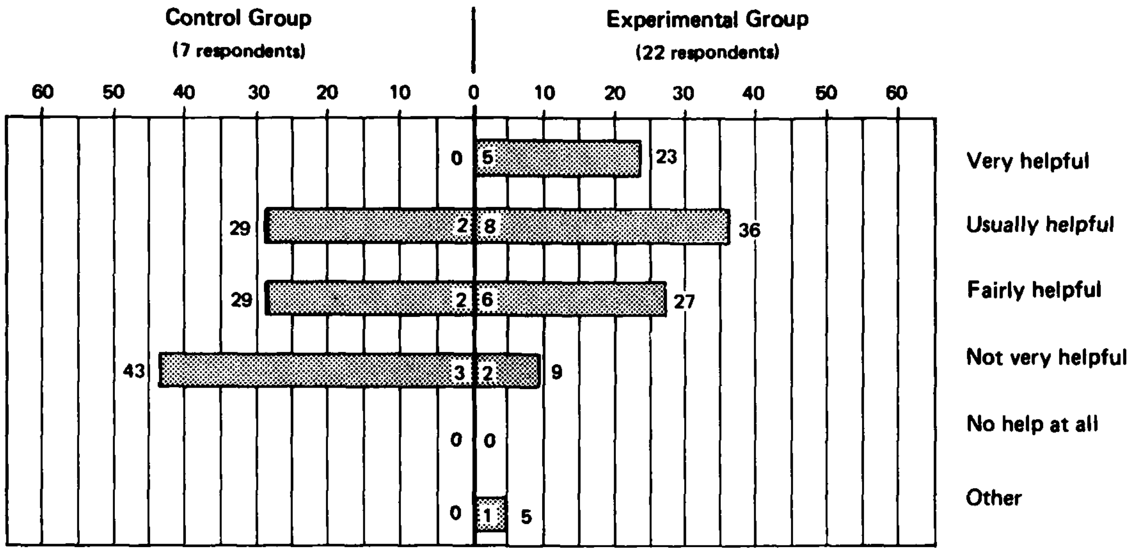
5. *Did you have any difficulty in understanding the procedures?*



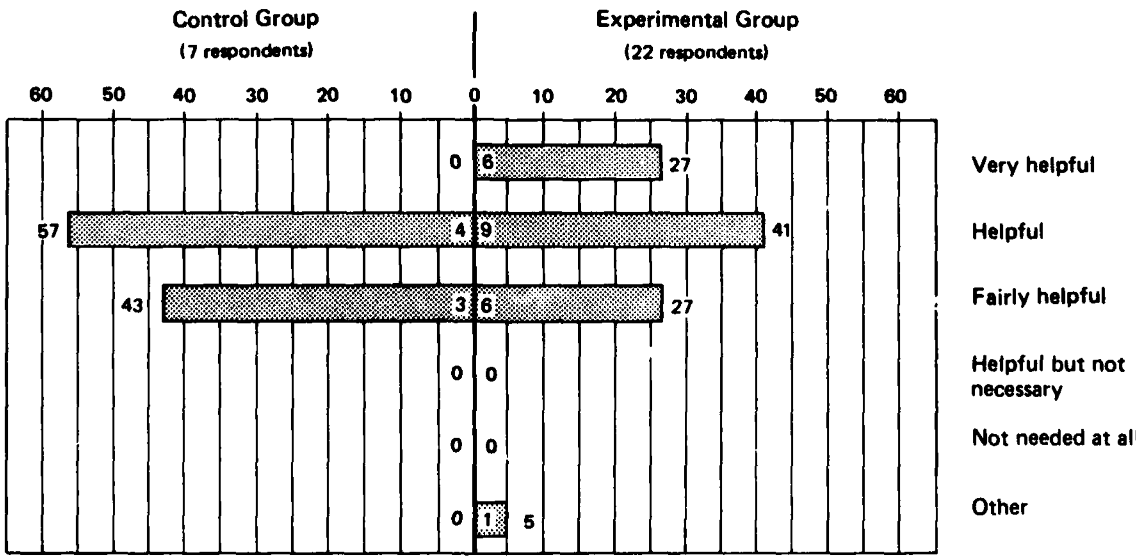
6. *Are the materials in the supplement well-organized?*



7. *Do you feel the organizational plan of the materials in the supplement was...*

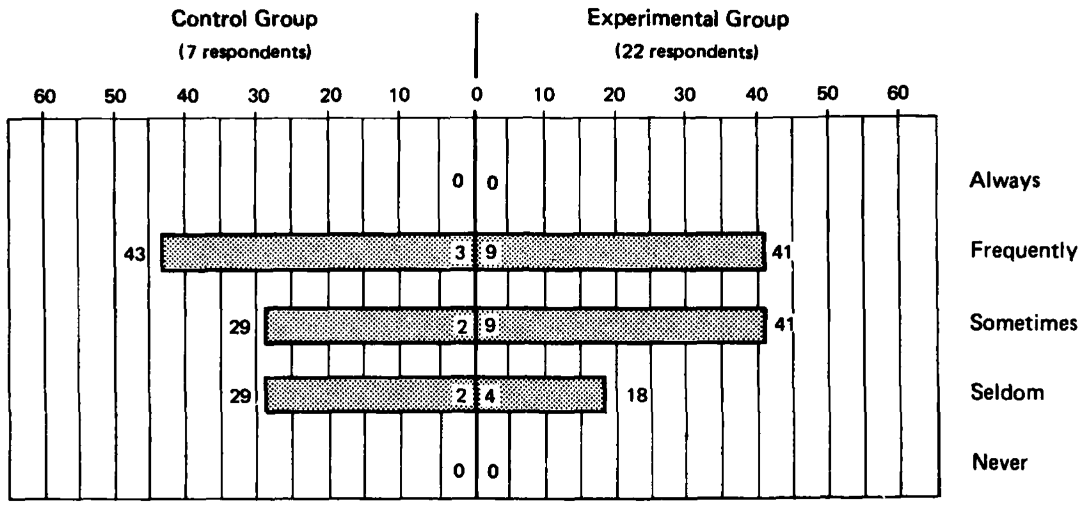


8. *The graphics were:*

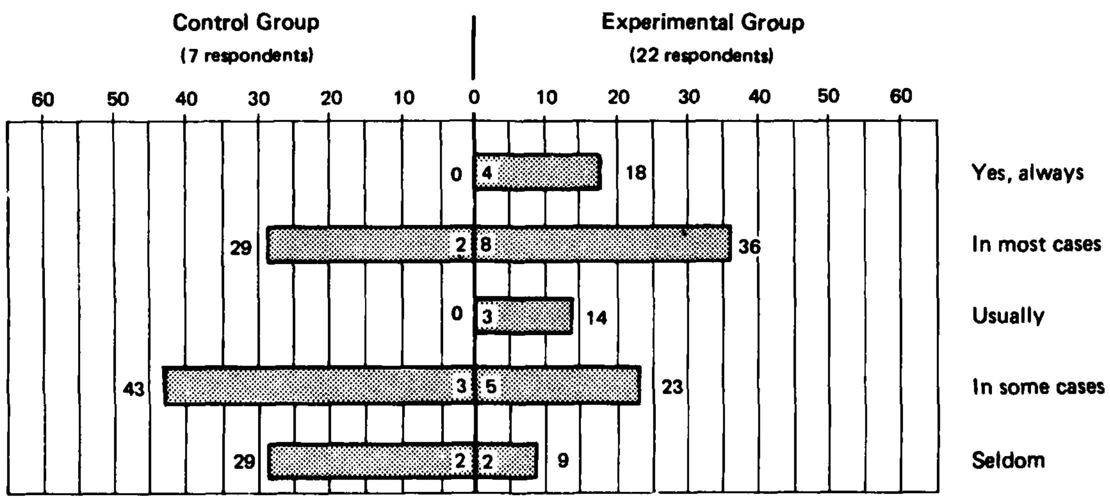


Student Naval Aviator (SNA) Responses to Questionnaire *(Continued)*

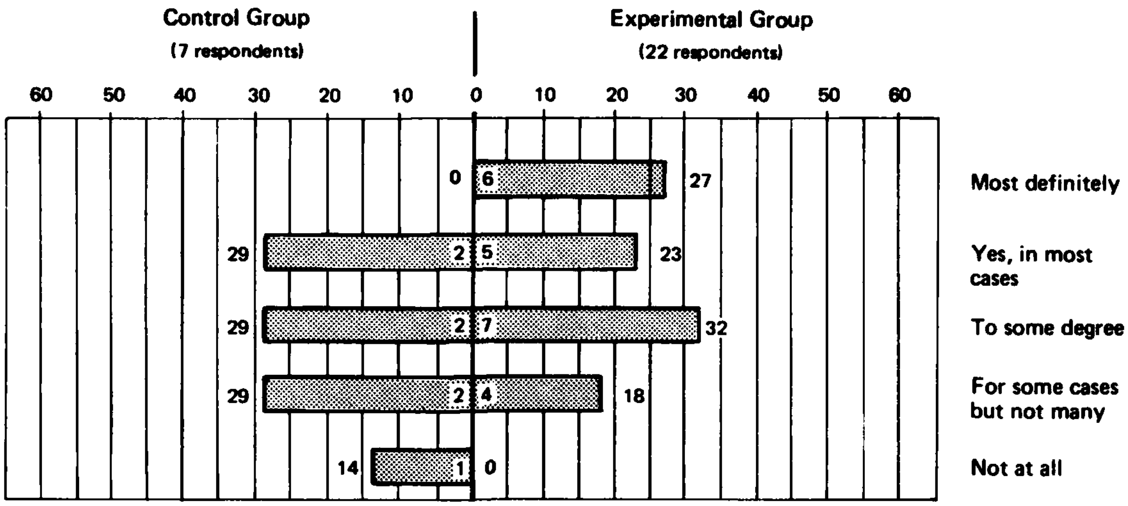
9. *To what extent do you feel the procedure headings helped you to memorize the materials?*



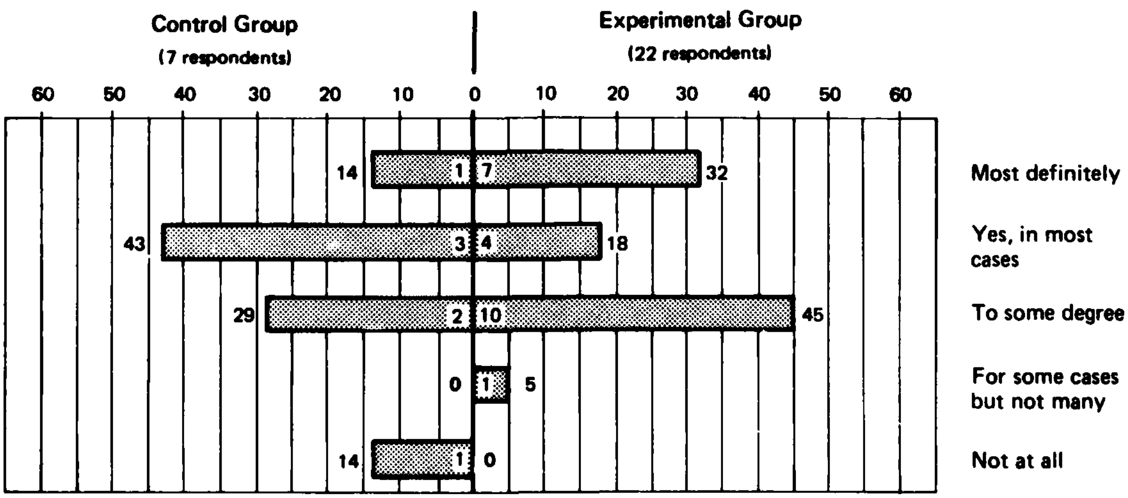
10. *Were the ejection standards for altitude and airspeed clearly defined?*



11. *Do you feel more confident about assessing the ejection envelope after reviewing the supplement?*

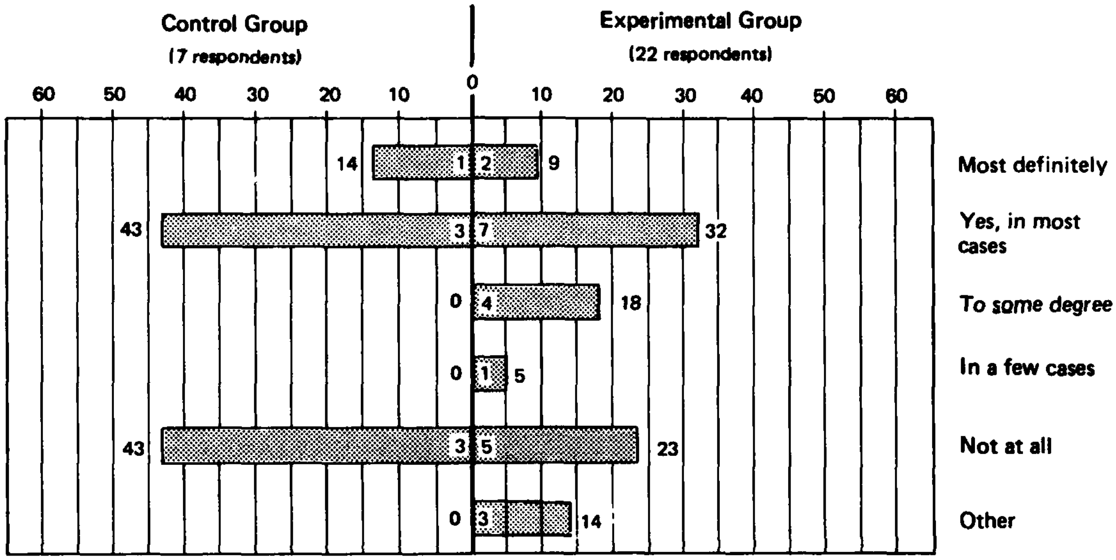


12. *Do you feel more confident in your knowledge of the ejection operation procedures after reviewing the supplement?*



Student Naval Aviator (SNA) Responses to Questionnaire *(Continued)*

13. *Do you feel more confident of your ability to locate ejection operation equipment as a result of using the supplement?*



Student Naval Aviator (SNA) Responses to Questionnaire *(Continued)*

14. The following features are to be rated as to their *contribution* towards helping you understand and comprehend the materials.

	Very Good		Good		Fair		Poor		Very Poor		No Response	
	C[a]	E[b]	C	E	C	E	C	E	C	E	C	E
1. Pictorial coverage of ejection equipment items.	29	32	43	41	14	23	14	5	–	–	–	–
2. Number of illustrations depicting ejection operations.	–	23	86	55	14	23	–	–	–	–	–	–
3. Pictorial coverage of envelope assessment equipment items.	–	9	43	73	57	18	–	–	–	–	–	–
4. The location and identification of ejection operation equipment.	14	18	57	55	14	14	14	9	–	–	–	5
5. The labeling of relevant ejection procedures.	14	14	57	59	29	18	–	5	–	–	–	5
6. ˙he organizational layout of the envelope assessment.	–	18	29	32	57	36	14	–	–	9	–	5
7. The explicitness of ejection operation procedures.	–	27	71	55	14	14	14	–	–	5	–	–
8. Placement of notes and warnings.	–	9	43	55	43	32	14	–	–	5	–	–
9. Readability of the envelope assessment text.	–	9	14	41	57	36	14	5	14	9	–	–
10. Overall appearance of the supplement.	–	–	43	77	43	18	14	–	–	5	–	–

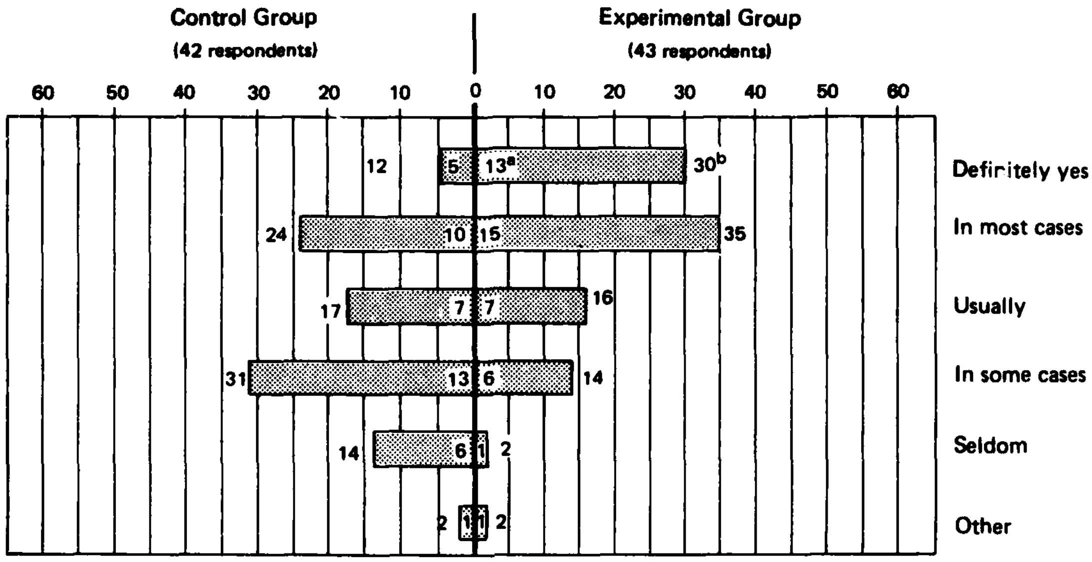
Note: Results are expressed in percentages of respondents.

[a]Control (unmodified materials).

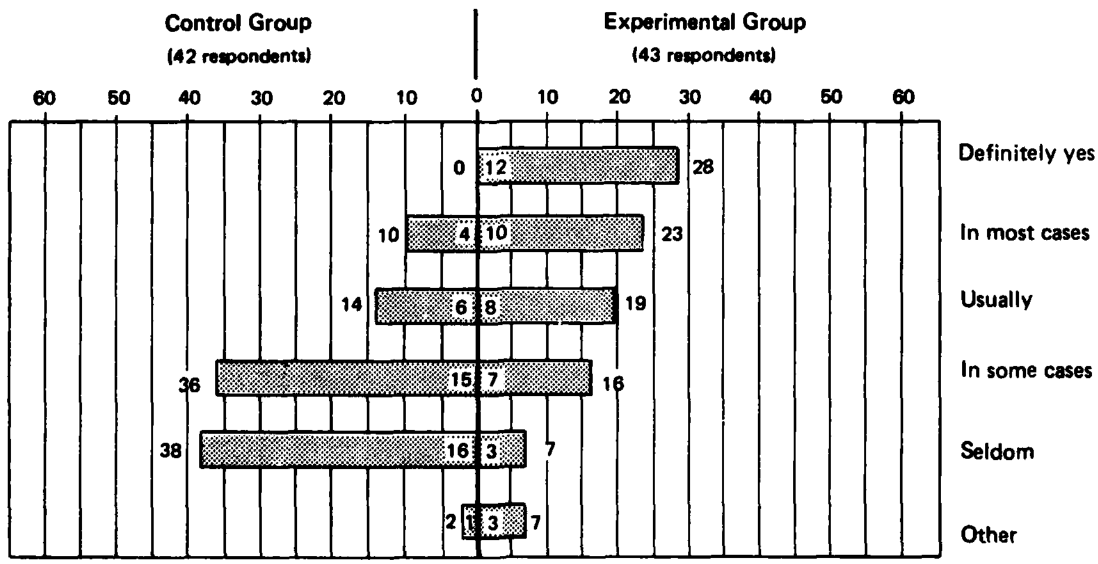
[b]Experimental (rewritten version).

Student Naval Flight Officer (SNFO) Responses to Questionnaire

1. *Were the illustrations helpful in recalling the ejection operating procedures?*



2. *Did the supplement help in the understanding of "safe" envelope assessment?*

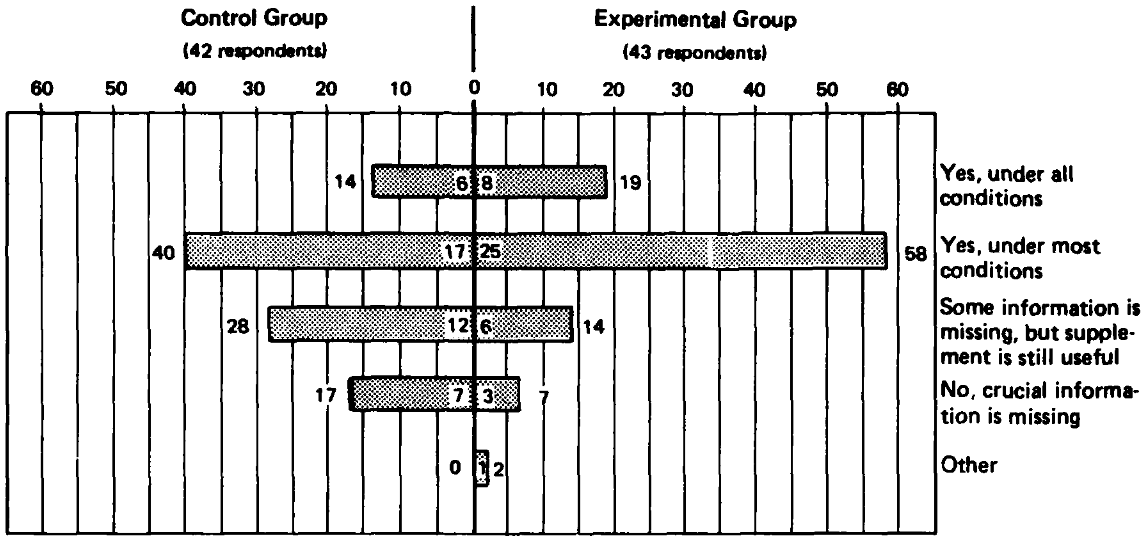


[a]Number at center is number of subjects that chose this response.

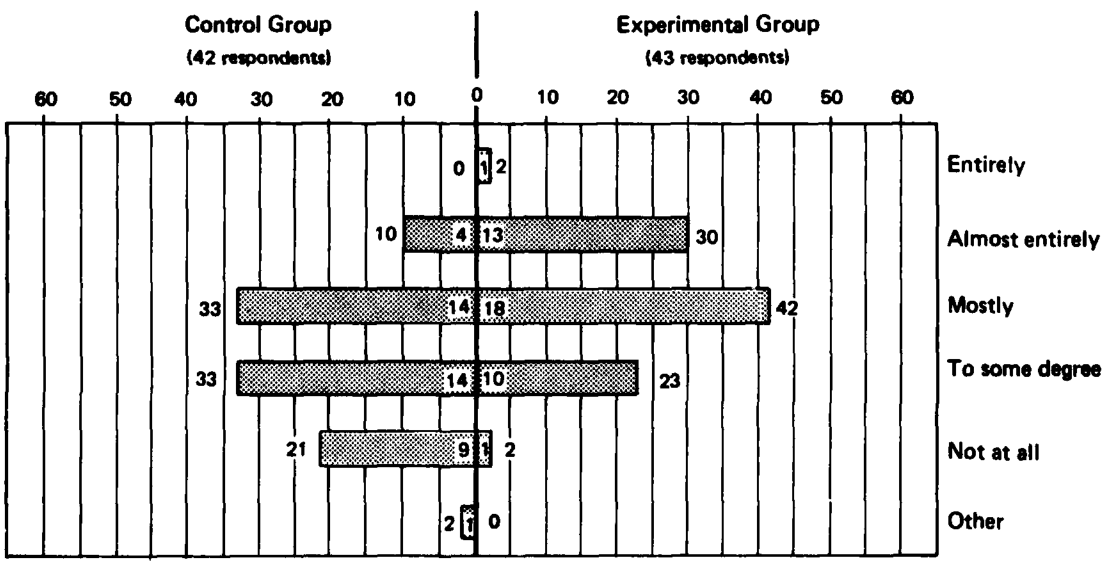
[b]Number outside bar (or at extreme tip) is percentage (approx.) of group represented by this number of respondents.

Student Naval Flight Officer (SNFO) Responses to Questionnaire *(Continued)*

3. *Does the procedure section contain the information needed to initiate ejection properly and safely?*

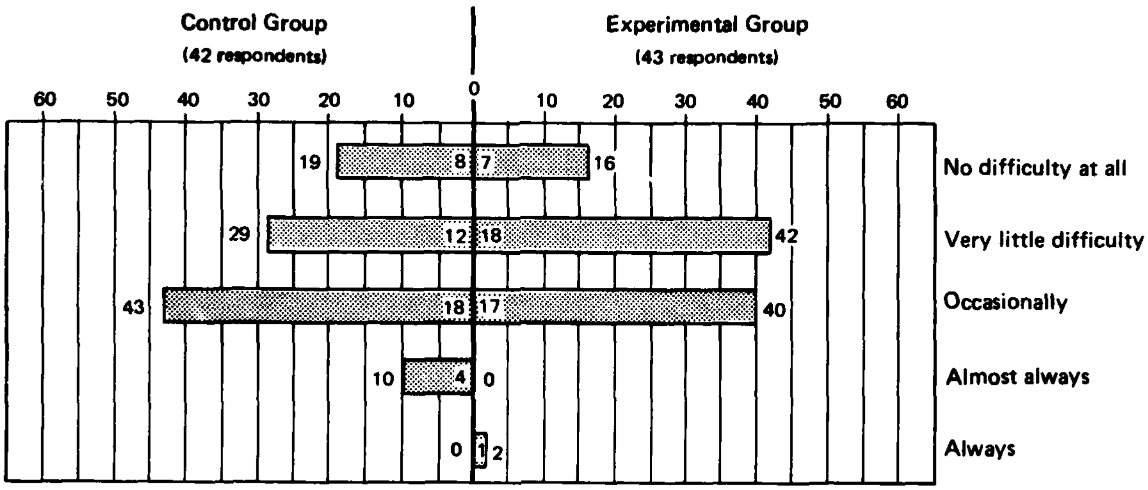


4. *Do you feel you have the ejection procedures mastered?*

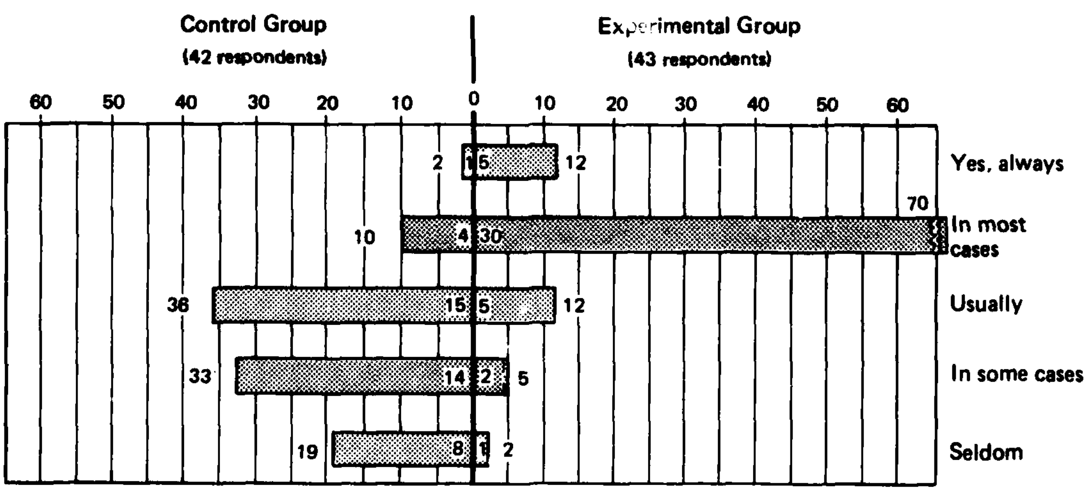


Student Naval Flight Officer (SNFO) Responses to Questionnaire *(Continued)*

5. *Did you have any difficulty in understanding the procedures?*

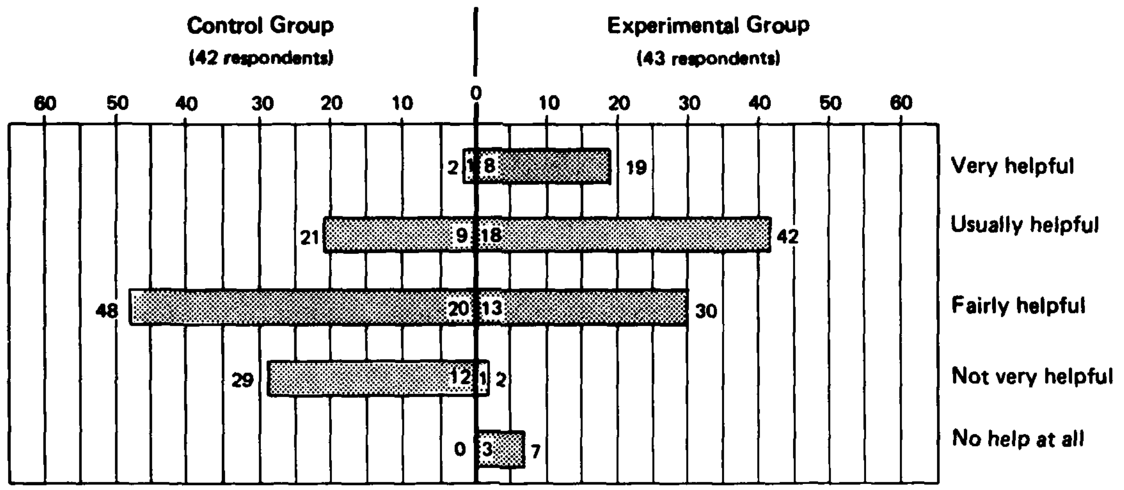


6. *Are the materials in the supplement well-organized?*

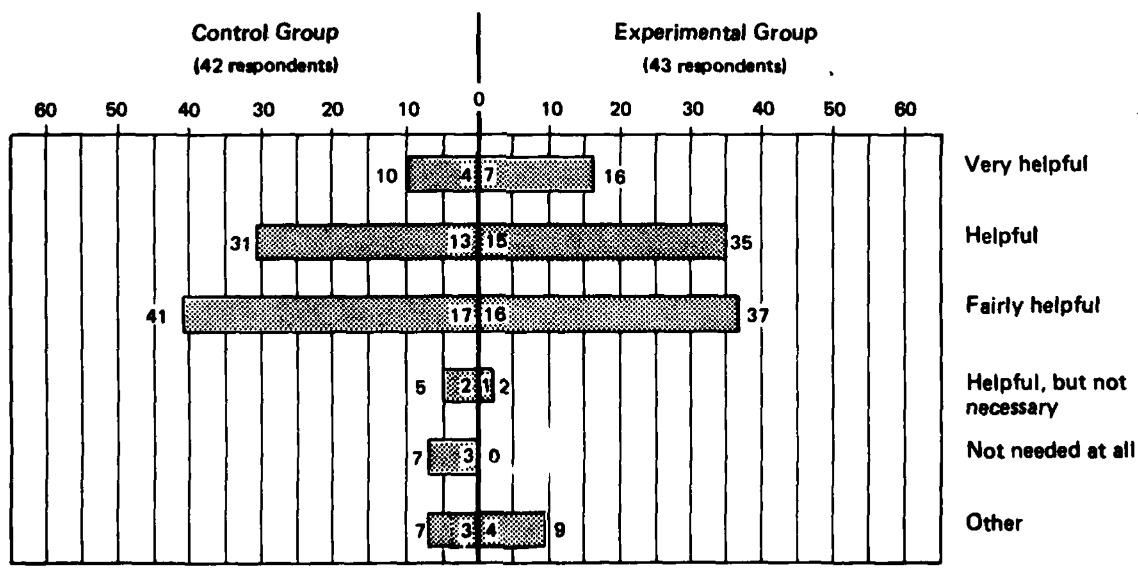


Student Naval Flight Officer (SNFO) Responses to Questionnaire *(Continued)*

7. *Do you feel the organizational plan of the materials in the supplement was*

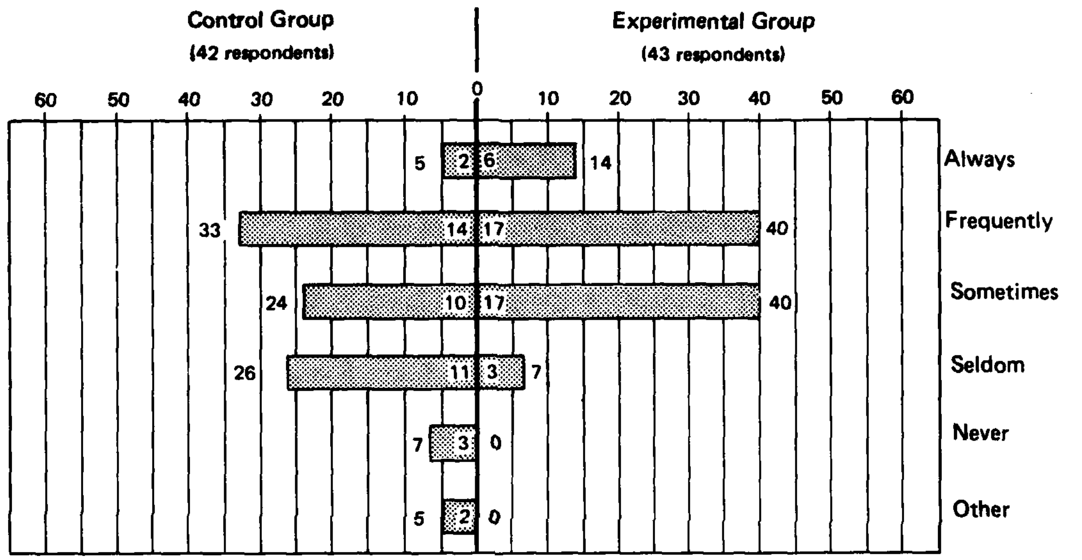


8. *The graphics were:*

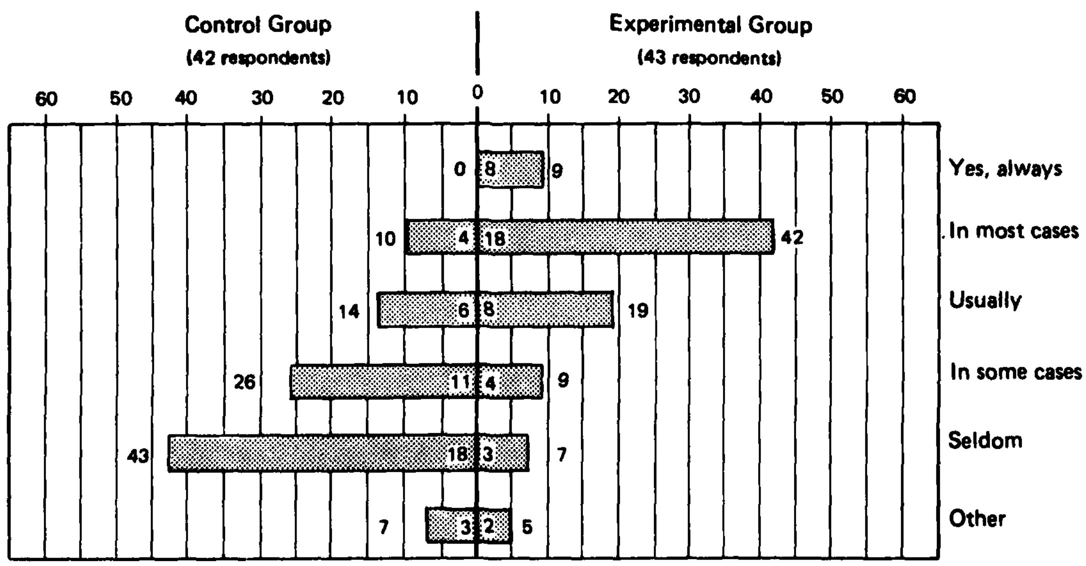


Student Naval Flight Officer (SNFO) Responses to Questionnaire *(Continued)*

9. *To what extent do you feel the procedure headings helped you to memorize the materials?*

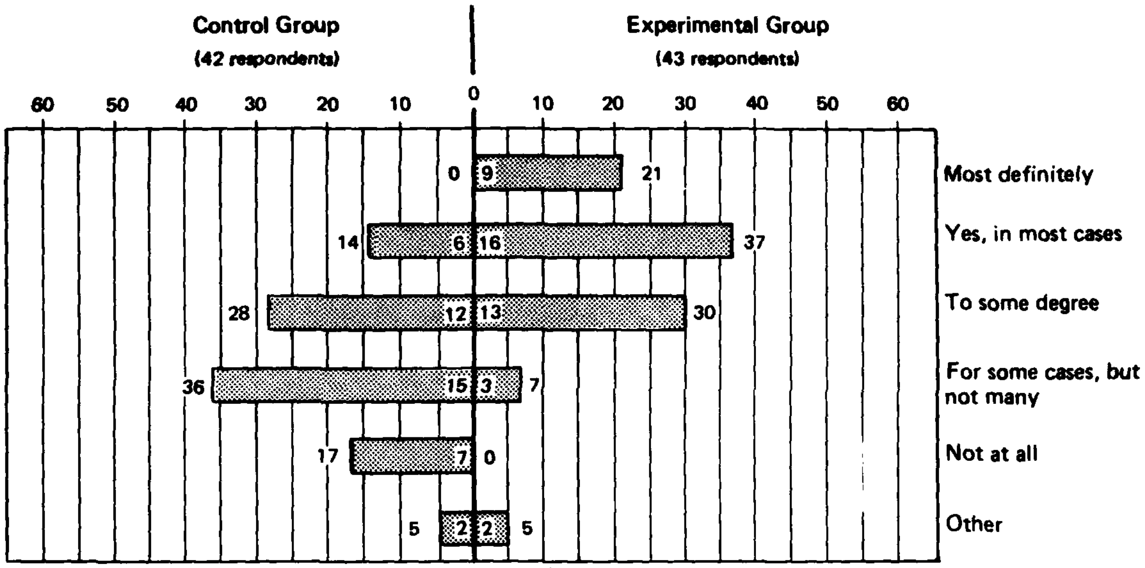


10. *Were the ejection standards for altitude and airspeed clearly defined?*

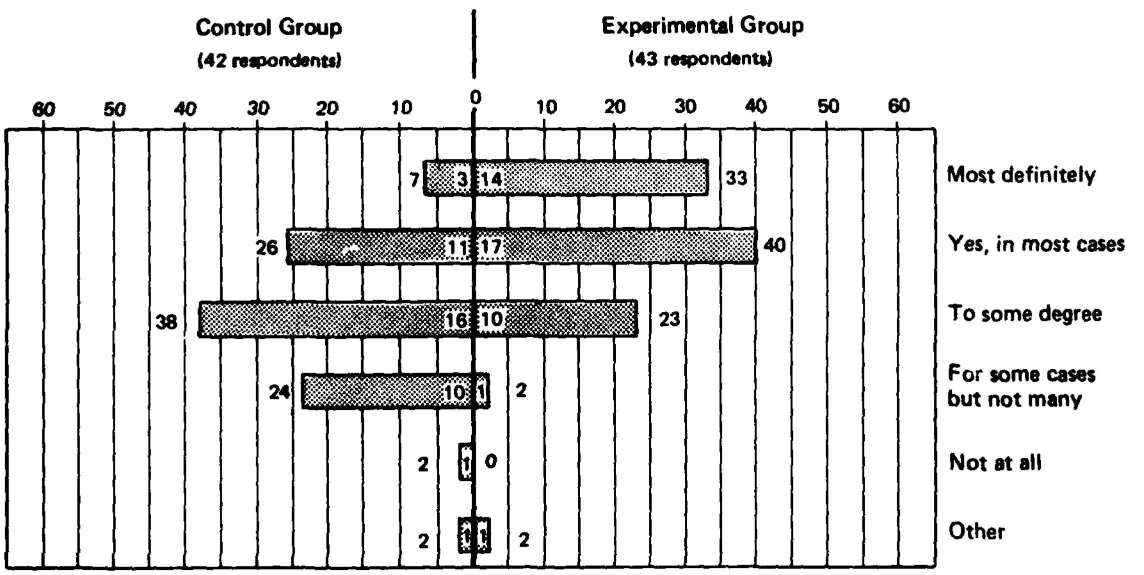


Student Naval Flight Officer (SNFO) Responses to Questionnaire *(Continued)*

11. *Do you feel more confident about assessing the ejection envelope after reviewing the supplement?*

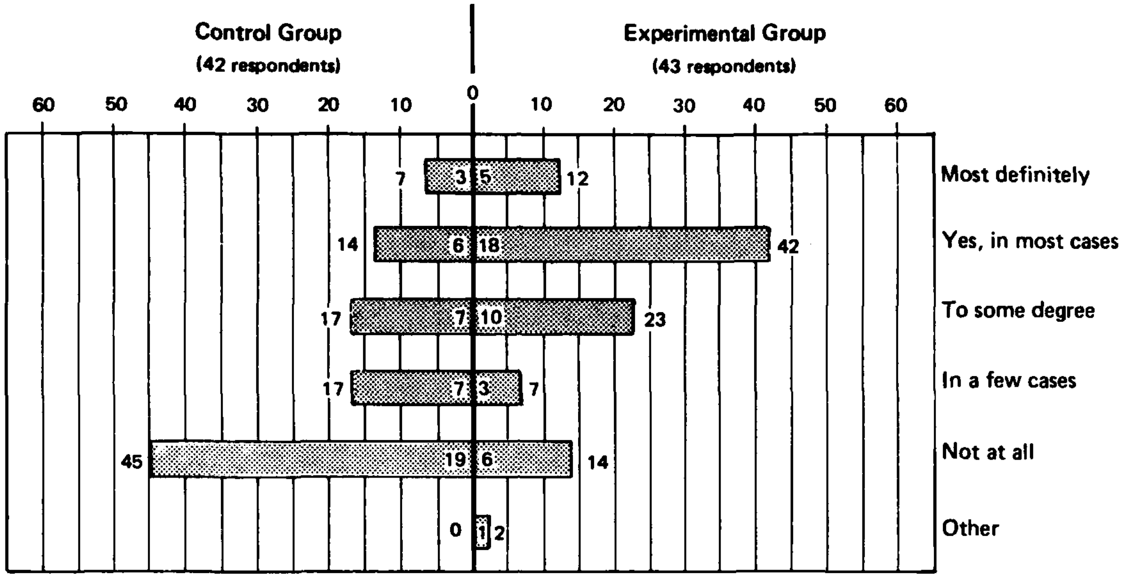


12. *Do you feel more confident in your knowledge of the ejection operation procedures after reviewing the supplement?*



Student Naval Flight Officer (SNFO) Responses to Questionnaire *(Continued)*

13. *Do you feel more confident of your ability to locate ejection operation equipment as a result of using the supplement?*



Student Naval Flight Officer (SNFO) Responses to Questionnaire *(Continued)*

14. The following features are to be rated as to their *contribution* towards helping you understand and comprehend the materials.

	Very Good		Good		Fair		Poor		Very Poor		No Response	
	C[a]	E[b]	C	E	C	E	C	E	C	E	C	E
1. Pictorial coverage of ejection equipment items.	14	19	28	42	31	26	19	9	7	5	–	–
2. Number of illustrations depicting ejection operations.	10	21	28	56	36	23	21	–	5	–	–	–
3. Pictorial coverage of envelope assessment equipment items.	–	12	19	23	26	37	33	26	21	–	–	2
4. The location and identification of ejection operation equipment.	5	12	21	30	14	26	36	19	24	7	–	7
5. The labeling of relevant ejection procedures.	12	21	38	53	36	26	12	–	2	–	–	–
6. The organizational layout of the envelope assessment.	–	7	19	44	33	33	33	12	14	5	–	–
7. The explicitness of ejection operation procedures.	12	16	43	58	38	16	7	5	–	–	–	5
8. Placement of notes and warnings.	10	21	33	47	33	16	19	12	5	5	–	–
9. Readability of the envelope assessment text.	2	7	19	21	17	51	40	14	21	7	–	–
10. Overall appearance of the supplement.	2	12	24	49	40	35	31	2	2	–	–	2

Note: Results are expressed in percentages of respondents.

[a]Control (unmodified materials).

[b]Experimental (rewritten version).

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